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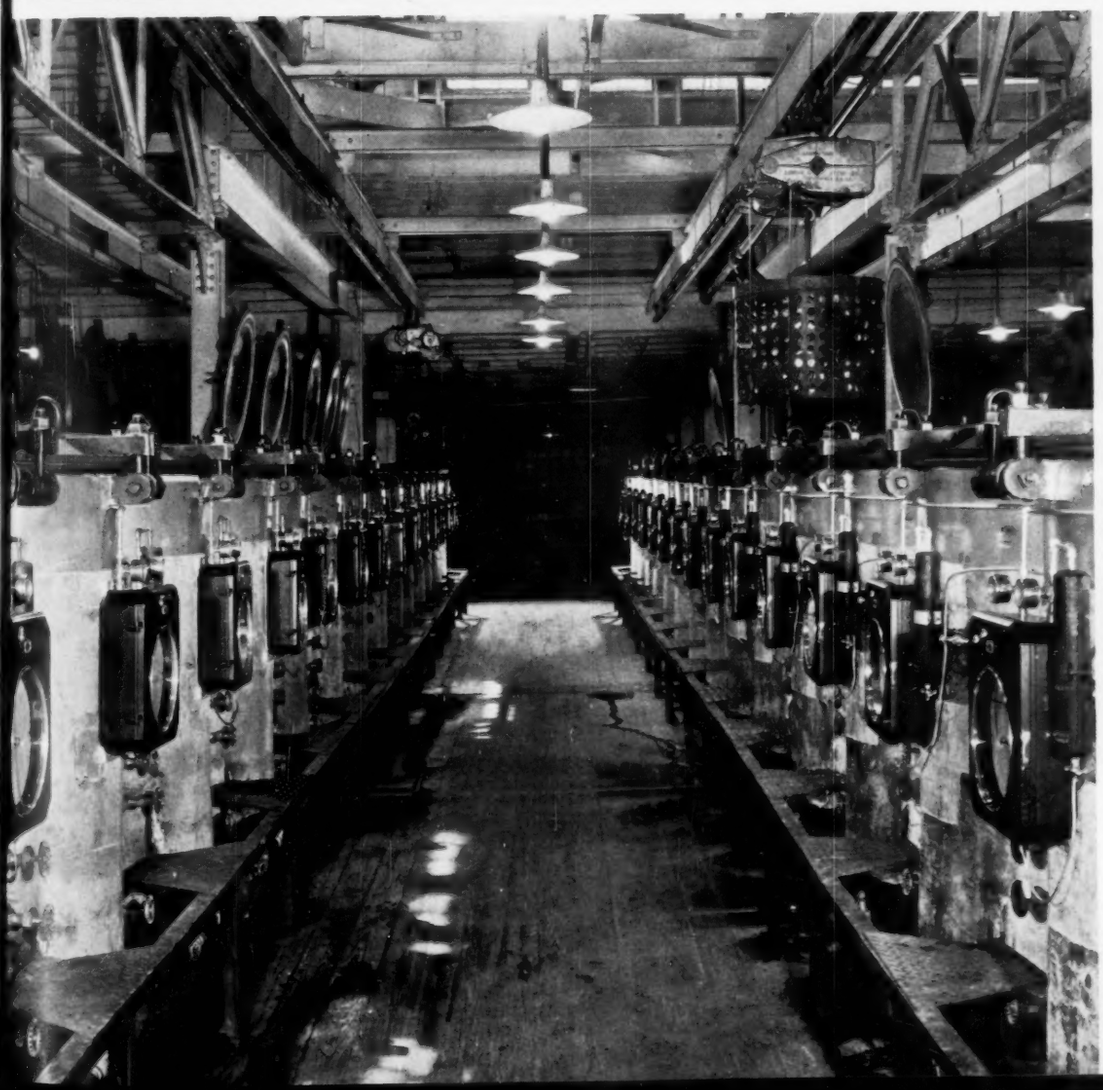
# INSTRUMENTS

## THE MAGAZINE OF

# MEASUREMENT and CONTROL



VOLUME 10

AUGUST
1937

NUMBER 8

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*ready for work!*

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INSTRUMENTS PUBLISHING COMPANY

# INSTRUMENTS

1117 WOLFENDALE ST.
PITTSBURGH, PA., U.S.A.

THE MAGAZINE OF
MEASUREMENT and CONTROL

September 15, 1937

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Courtesy Taylor Instrument Companies

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INSTRUMENTS The Magazine of MEASUREMENT and CONTROL

M. F. BEHAR
EDITOR

## IN THIS ISSUE

Walton Forstall, Jr., who describes instrumentation at the Philadelphia Gas Works Co. (where he is Engineering Assistant) took his B.S. in M.E. at Lehigh in 1931 and served on the Technical Staff of the Franklin Institute Museum before joining PGW in 1934. He represents the third generation of Gas Engineers in his family!

Professor Williams devotes this month's instalment of his serial "Hardness and Hardness Measurements" to the early scratch hardness methods.

Shannon's articles discusses the installation of liquid level indicators and how operating conditions may modify the pipe work connections.

For the study of high-speed transients the cathode-ray oscillograph was first used as a recording instrument by Dufour in 1918. However, extensive practical application of the oscillograph for this purpose did not occur until about ten years ago. Batcher gives general details about the tubes and their uses.

## THE FRONT COVER

No empty words in this year's canners' slogan, "Quality pack for 1937." This photograph taken in the retort room of a mid-western canning and packing plant bears bountiful evidence of instrument-mindedness. Not shown are four more rows of retorts similarly equipped by the Taylor Instrument Companies.

# GADGETEERS

*American Falls, Idaho, July 27, 1937*

IN every industrial plant that has survived the depression—and particularly in every plant that has never stopped showing profits—there is to be found at least one unsung hero: the chap who saves money by "putting gadgets on old processing equipment so it works like the new types we thought we'd have to buy" and who makes money by increasing the productivity of existing processing equipment.

As a rule, this man achieves his results by applying the fundamental doctrines of Instrumentation: (1) Eliminate the variables by reducing them to measurable magnitudes; (2) Whatever is to be controlled should first be measured; (3) If you can measure it you can control it; (4) If you can control by hand you should control automatically.

It is in the practical application of these theories that each man gets his chance to display his talent—not to say his genius—for scientific management, financial management and displomacy. Your editor has been gaining a new insight into this problem in the course of his leisurely trip through the Rocky Mountain States, where industrial plants are few and far between; and has been gaining a new respect for Instrumenticians (whose official titles range from "instrument mechanic" to "Vice-President in Charge of Operations").

Only, they're not called Instrumenticians. In two establishments, the unsung heroes were called "Edisons," in two others they were referred to as "gadgeteers."

Eastern and Pacific Coast *Instruments* readers, who are frequently called upon by sales engineers, who attend meetings of local branches of engineering societies, who need only pick up the 'phone to have a service man come a-rushin' and who are right in the midst of things—technically speaking—cannot imagine to what extent their Rocky Mountain colleagues must rely upon their *own* ingenuity and resourcefulness. In Utopia, of course, every engineer would have an unlimited budget for the purchase of instruments, testing devices, automatic controllers, meters and accessories. But the unpleasant truth is that absentee owners in big-city office buildings usually balk at the prices of remote-type industrial instruments and control systems in remote plants. In spite of this stupidity (out here we feel like calling a spade a spade) the resourceful gadgeteers contrive to beg, borrow or "promote" a tube-system here, a relay there, a diaphragm-valve here, a clockwork there, and they achieve miracles of measurement and of automatic control with miracles of ingenuity.

# No. 27—Erich Fetz, Research Metallurgist
# No. 28—Edwin W. Barmore, Physicist

**Wilbur B. Driver Co., Newark, N. J.**

By M. F. BEHAR

IN all the world, there probably is no more elaborate ASTM life test board for resistance wire than the 64-position board of which a corner is shown here. That's what your reporter thinks, although Dr. Fetz—chiefly responsible for this and other modern set-ups—would only admit that "There are few test boards of this type in the U. S. A." Nevertheless, Fetz and his assistant Barmore are so proud of this board that they readily followed the suggestion that they be introduced to you in front of it—not "posed" but really "at work." Which was natural, for resistor materials are the bulk of the company's business and life testing consequently the backbone of Fetz's research.

Born in Germany in 1903, Fetz received the degree of Diplom Ingenieur "with distinction" in 1927. As an International Exchange Student he did post-graduate work at Carnegie Tech in '28 and '29; and began at that time to abstract foreign technical journals for *Instruments*, of which he was a Charter Subscriber. Before September 1935, when he assumed his present position, he did research work in several metallurgical plants, among them the Crucible Steel Co., where he developed a dynamic hardness tester for high-temperature-duty steels. Since 1934 he has been devoting much of his spare time to X-ray research at Columbia University and has attained such refinements of precision that his results will probably stand for many decades to come.

Having been brought up on the shores of the North Sea, Fetz was impelled by the old Hanseatic spirit to make his first trip to the U. S. when he was twenty-one. It was then (1924) that he decided that he would settle here after finishing his academic courses in Germany. When asked about his hobbies, he replied, "First, metallurgical research. This is no joke!" He is fond of water sports, spends much time *on* the water in his boat or *in* the water, swimming. As a college athlete he won 186 prizes, one intercollegiate championship and two national championships in swimming.

In contrast to the much-traveled Fetz, Barmore has lived mostly in the vicinity of Newark. Born in Kearny in 1907, he attended Bloomfield High School, Newark Tech, and Drexel. Then five years with General Electric at Bloomfield and Philadelphia, two with Western Electric at Kearny, and since 1935 in his present connection. He has a wife and two children, and his great hobby is "tinkering in the cellar" in his well-equipped chemical laboratory or at his various pieces of electrical equipment.

The production of Ni-Cr and Ni-Fe-Cr alloys being both a science and an art, extremely close control is exercised in melting these materials in the company's Ajax high-frequency induction furnaces. Fetz is convinced that any research metallurgist must thoroughly know the limitations of existing testing methods; he believes that there is a tendency in many colleges to neglect Materials Testing in their metallurgical courses; and he keeps up with latest developments not only by contributing to the advance of the art but by making abstracts of technical articles—at the rate of hundreds a year—from periodicals in eight foreign languages. Fetz and Barmore are introduced here as fairly typical of the company's technical personnel. Every member of the Engineering Department, for that matter, is a regular reader of *Instruments*.

Among the results are modern instrumentation methods as well as equipment. The list on this page can only convey an idea of the equipment; it would probably take a week's visit to appreciate all the ingenious methods.

### WILBUR B. DRIVER CO. INSTRUMENTATION

#### 1. ELECTRICAL TESTS

*Instruments For Measuring Electrical Resistance.*
L&N Portable Wheatstone Bridges ..... 10
L&N Portable Kelvin Bridges ..... 6
L&N Kelvin Standard Bridge ..... 1
*Instruments for Temperature Coefficient Tests.*
L&N Variable-ratio Wheatstone Bridges ..... 2
*Instruments For Measuring Thermal Emf.*
L&N Portable Potentiometer ..... 1
Thwing Treasure Chest ..... 1
Queen Standard Potentiometer ..... 1
*Equipment for Life-testing Resistance Wire.*
A.S.T.M. Standard Life Test Positions ..... 64
Bench Board for Testing Complete Appliances, 15,000 Watt Capacity ..... 1
*Equipment For Testing Dielectric Strength of Insulation.*
High-tension Breakdown Tester ..... 1
Low-voltage Testers ..... 4
*Instruments For Indicating, Recording and Controlling Temperature*
Brown 6-point Recording Pyrometer ..... 1
Brown 2-point Recording Pyrometer Controllers ..... 4
Brown Indicating Pyrometer Controllers ..... 4
Bristol Indicating Pyrometer Controllers ..... 3
Wilson-Maeulen Indicating Pyrometers ..... 4
Foxboro Pyrometer Controllers ..... 17
Thwing Pyrometer Controllers ..... 1
L&N Indicating Pyrometer ..... 1
Thwing 2-point Recording Pyrometer ..... 1
Portable Potentiometer ..... 1
Optical Pyrometers ..... 2
Accessories include: Standard cells, Standard resistances, Galvanometers, Furnaces, Oil baths, Stoves, etc.

#### 2. PHYSICAL TESTS

Tensile Machines ..... 3
Rockwell Hardness Testers ..... 2
Rockwell Superficial Hardness Tester ..... 1
Scleroscope ..... 1
Torsion Machine ..... 1

#### 3. METALLURGICAL AND METALLOGRAPHIC

Zeiss Photomicroscope ..... 1
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Ajax Furnaces ..... 6

#### 4. SIZE INSPECTION

Hand Micrometers ..... 110
Box Micrometer ..... 1
Zeiss Bench Micrometer ..... 1
Torsion Balances ..... 10

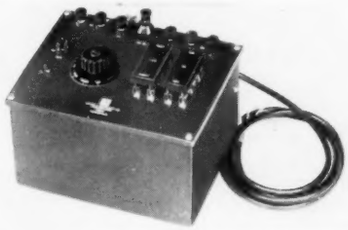
#### 5. CHEMICAL

Laboratory completely equipped to control cleaning operations and maintain other chemical operations throughout the plant. Analyzes raw materials and finished product to assure quality and uniformity.

# THE MONTH'S NEW INSTRUMENTS

## Insulation-Resistance Test Set

Using a guarded circuit, this new insulation resistance test set is entirely free from the effects of leakage currents. The instrument conforms with the ASTM "Standard Methods of Test for D-C Resistance of Insulating Materials" —No. D-257-37T. Switches are designed to simplify operation and eliminate calculation. Calibration of the galvanometer



deflections is facilitated by the specially designed Ayrton shunt. Simply turning the shunt to the calibrating portion automatically connects the circuit for calibration. Results are obtained by merely dividing the calibration reading by the test reading.—*Leeds & Northrup Company, 4955 Stenton Avenue, Philadelphia, Pa.*

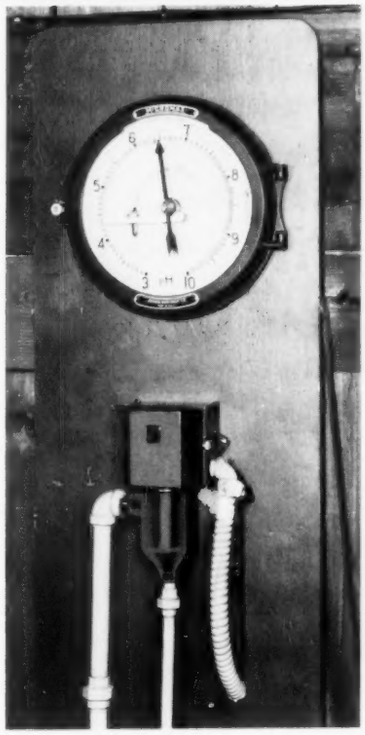
## Buried Pipe & Cable Detector

The "M-Scope" consists of a radio transmitter, in one box, and a radio receiver, in the other, the output of which is fed to an indicator in the face of the receiver and to a pair of headphones. To use the device, the transmitter and receiver are carried in the suspected direction of the pipe or cable, with the headphones in position. As the pipe is approached the tone in the head set will increase to a maximum. The maximum signal level can also be read on the instrument and spot marked on the ground or street. The "M-Scope" weighs 22 lbs. complete; is self-contained; standard dry cells furnish the power required.—*Fisher Research Laboratories Sales Co., 45 Rockefeller Plaza, New York, N. Y.*

In this department we strive to report each month ALL the new devices for measurment, inspection, testing, metering and automatic control—in the form of concise technical descriptions.

When writing to manufacturers directly, please mention this department as your source of information.

Or write to Information Section, Instruments Publishing Company.

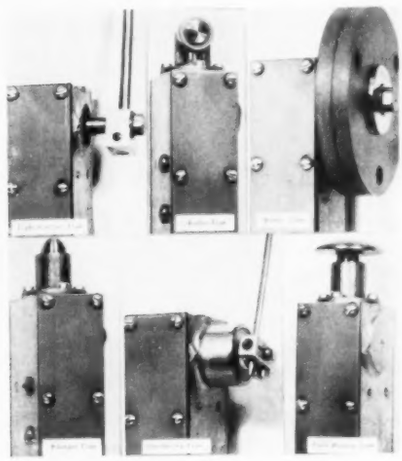


## Boiler Water pH Instrumentation

For industrial and power-plant boiler rooms, water purification plants, oil refineries, and process industries, a new equipment provides automatically a continuous guide to pH of treated water, a continuous record of it and, where desired, continuous automatic control over the addition of a reagent. An electrode assembly detects pH of a continuously flowing sample of treated water, and maker's standard "Micromax" makes this information available at convenient location distant from sampling point. Where control is manual, operator "sees" pH at any time by glancing at the indicating scale of a recording instrument and he adjusts reagent input accordingly. Or he sees what the pH was at a previous time by examining the chart record. Where control is automatic, operator turns a control setter to desired pH value. Thereafter any deviation in pH of treated water from this value brings about an immediate adjustment of reagent input: small deviations resulting in small corrective adjustments; large deviations in correspondingly larger adjustments.—*Leeds & Northrup Co., 4955 Stenton Ave., Philadelphia, Pa.*

## Super-sensitive Line Voltage Switch

The new Namco super-sensitive line voltage switch has many applications. It may be used as limit switch, safety switch, or in connection with counting devices, circuit breakers, liquid level controls, gauge devices, relays, pressure controls and governors. The switch is made in five different types as illustrated. These are rotary, light contact, oscillating, plunger and push types. The rotary switch is particularly adaptable where revolution contacts, linear measurement wheels, star wheels, etc. are to be used. Light contact switch is used for applications requiring an extremely light touch to make or break the circuit. The switch may be actuated by a pressure of only one ounce with a nine-inch lever. The oscillating type switch makes contact in one direction but not in the opposite direction. It has many applications in the machine tool field. The plunger or push type switches require less than 1/16" movement for contact and allow an additional 3/16" for overtravel. They may be used as limit, safety or cam-operated



switches. The main shaft controlling the operating mechanism in the rotary and light contact switches is substantially supported in oil seal ball bearings. The internal operating levers in all models are equipped with an adjustable steel spring, insuring correct pressure on the contact button. Actual electrical contacts are made in the fully-enclosed, dust-proof, molded, removable Micro Switch. The general design is such as required for rapid contacts and continuous operation. Provisions have been made to wire for normally open or normally closed contacts. Standard mounting of all these switches is made with two $\frac{1}{4}$-20 screws, entering the two tapped holes provided in the bottom of the housing. Other mountings are easily adaptable to meet requirements, by applying special bottom plates. The rapid snap action of the contacts, the generous use of silver in both contacts to dissipate heat and the size of the switch gap all make it possible for the Micro Switch to break large currents.—*National Acme Co., Cleveland, Ohio.*

BAILEY METER CONTROL SYSTEM

*The Mark of*

## Effective Control

**Process Control** for sensitive, stable automatic control of temperature, pressure, liquid level, flow and other factors as applied to industrial processes. Responds to changes quickly, without overtravel or hunting. Ask for Bulletin No. 101.

**Combustion Control** that is simple but *complete* for providing economical operation of boilers of 200 h. p. and larger. Details in Bulletin No. 102.

*Recorder-Controller*

**Boiler Meters** for recording combustion conditions and guiding boiler operators. Described in Bulletin No. 44.

**Multi-Pointer Gages** for indicating factors such as draft, pressure, temperature and speed. These Gages are available with any number of pointers and any scale combination; in either the oil sealed bell or diaphragm construction.

*Control Drive*

**Flow Meters** for indicating, recording and integrating the flow of steam, water, sewage, air, gas and other fluids. Bulletins No. 39 and 300.

**Recorders** for pressure, temperature, drafts, liquid level and other factors.

G-3

**BAILEY METER COMPANY**

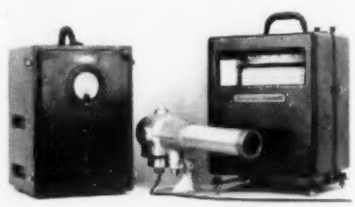
**1041 Ivanhoe Rd., Cleveland, Ohio**

## Rolling-mill Pyrometer

"Developed for the express purpose of providing the rolling-mill man with adequate means of accurately measuring temperature of the steel in motion as it is passing through the rolling mill," this new equipment, known as "Bristol's Electronic Instagraph," consists of a photoelectric-cell receiving-tube unit, a potentiometer amplifier and a recording instrument. It is said to represent a "new method" of temperature measurement, "basically different from any other available instrument intended for similar purposes."

(1) *"Thermo-Photronic" Tube.* In this unit the sensitive element is a Weston Photronic self-generating type cell, in front of which is located a special filter-glass "to prevent infra-red or directly-radiated heat rays from reaching the sensitive surface of the cell." Baffles prevent extraneous rays from reaching cell. A lens closes outer end of tube and completes optical system for specified range. "The Photronic cell is affected by the thermal spectrum only."

(2) *Potentiometer Amplifier.* This unit is a d-c. amplifier operating on the potentiometer principle. It supplies to the recording instrument an amplified current directly proportional to the value of the applied voltage, with no energy drawn from the Photronic cell. Its galvanometer differs from those of conventional design in that it has no control springs; and as its deflections are optically magnified, balancing action is effected with an "almost infinitesimal coil movement." Consequent minimization of inertia and use of highly sensitive type of element render response and balancing "practically instantaneous." Standard radio tubes are used in amplifying system and circuit is such that normal tube decay cannot impair accuracy of measurement. While this unit is truly a potentiometer, it employs no standard cell, its accuracy depending on standard resistors. Except for the mirror galvanometer, there are no moving parts, no motors, cams, bearings, etc. Circuit is independent of sudden or gradual changes in line voltage up to 20%.

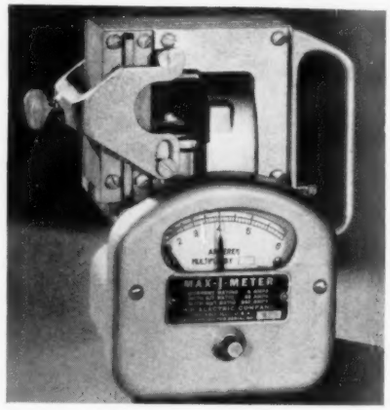


(3) *Recording Instrument.* This is a direct-marking type recording milliammeter with scale graduated in temperature based on response of Photronic cell (and optical system) of radiation-receiving tube unit. High-speed cobalt magnet movement is designed to give highest torque and speed consistent with proper damping characteristics. A relay is built into this recorder, which serves to stop the chart drive when indication reaches lower limit of temperature scale, thus avoiding wastage of chart paper between significant measurements. Range is 0-2250°F. Graduations represent 10°F. and are $\frac{3}{16}$" wide at 2100°F. and $\frac{1}{4}$" wide at 2250°F.

*Other Uses.* Entire equipment, or units thereof, find many uses other than temperature measurement of moving objects, wherever rapid recording of currents as low as 5 ma. or voltages as low as 2 mv. may be required.—*The Bristol Co., Waterbury, Conn.*

## Maximum Demand Tester

In using the new H-D Max-I-Meter, a split-core current transformer known as Max-I-Tran is arranged so the core jaws can be slipped over a conductor and clamped tight shut. The output from the current transformer feeds a built-in thermal-type meter. The heating effect of the current actuates a red hand, which carries a black hand with it, across the dial. The red hand follows, with a 30-minute time lag, the variation in load on the distribution transformer. The black hand remains in the maximum position reached by the red hand and is



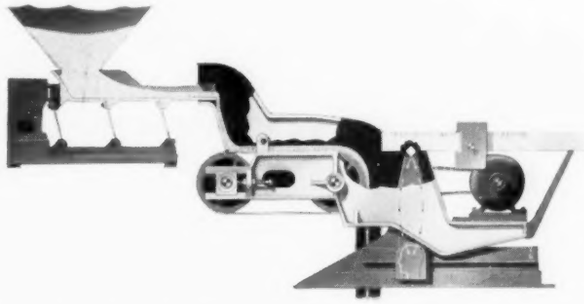

therefore a maximum-demand indicator. Being thermally operated the meter is not responsive to instantaneous or brief load fluctuations but instead integrates the heating effect of the load. The device is hung over a transformer conductor ( it weighs 13 lbs. and needs no additional support) and is left for the desired test period—usually one or two days. The reading of the maximum demand is taken, the black hand reset to zero and the meter is ready for another test or to be used elsewhere. The Max-I-Meter comes in four current sizes all weatherproof and self-contained. On each, different meter ratios can be obtained by making a simple tap change. The Max-I-Meter is accurate to ± 3%.—*H D Electric Co., 100 W. Monroe St., Chicago, Ill.*

## Frequency Modulator

"Model OA-5" universal electronic frequency modulator, with visual alignment, electronically operates with any oscillator or any size oscillograph to simplify a.f.c. alignment and to provide a method of locating intermittent trouble. It supplies synchronized horizontal sweep voltage for oscillographs, has calibrated sweep continuously variable from 5 to 40 kc. and calibrated phasing control gives direct-reading selectivity measurements. Output is continuously variable from 1 microvolt to over 1 volt. Instrument has complete self-contained power supply. There are no rotating and vibrating parts.—*The Hickok Electrical Instrument Co., Cleveland, Ohio.*

## Constant-weight-rate Feeder

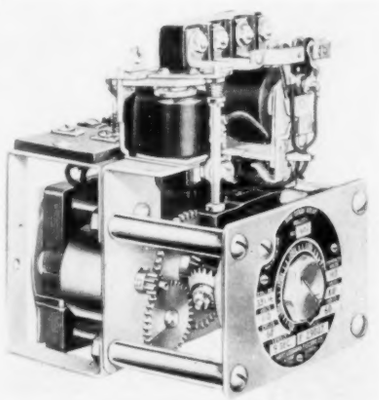
Applicable to continuous weigh-feeding, proportioning and batching, new "Waytrol" is said to be the only gravimetric feeder combining the following three features: (1) all-electric vibrating feeding, (2) synchronous weigh-belt on a scale beam so pivoted as to receive material at its more sensitive end, (3) automatic all-electric control including a device known as the "Electric Brain"—indicated by outline of human head in illustration. Feeding and weighing are physically separated and rate of feed to the weigh-belt is independent of volume of material handled. This rate of feed



is governed by weight through "Electric Brain" which detects unbalance and makes instant correction by speeding up or slowing down the vibrating feeder. Weigh-belt or beam is fed at its "live" end in order to give it utmost sensitivity; and common sources of inaccuracy are said to be non-existent by reason of the beam's being required to do no work except to weigh: movements resulting from unbalance are made without making any contacts and with no friction other than that of single knife-edge fulcrum. Feeding rate on a weight-rate basis is established by setting the counterpoise on the scale arm (right-hand in illustration) of the balance. Weigh-belt is driven at constant speed by a synchronous motor and its speed is initially set for maximum weight-rate of the particular material and application. This speed is not changed while this particular material is handled, even though feeding is reduced (by setting of counterpoise) to its lowest rate. Gravimetric feed rate is maintained regardless of variations in volumetric properties of material handled. Discharge from weigh-belt is to a fixed chute on base frame. A wiper prevents sticking of material on belt, which is enclosed in an aluminum housing integral with beam. To avoid wind-pressure error where strong and variable air currents prevail, entire unit is enclosed in steel box with two sides equipped with sliding glass panels. Feed-control panel, electrically commanded by "Brain" unit, may be located at any convenient place regardless of distance. Flasher lights on front of this control box give visual indications of operations. "Waytrol" is available in sizes to feed from a few pounds to "many tons" per hour.—*The Jeffrey Mfg. Co., Columbus, Ohio.*

## Time-delay Relays

"Bulletin 362" time delay relay has definite adjustable time intervals—beginning with 35 seconds and including 1.75, 5.75, 12.25, 26.25, 42, and 63 minutes. The relay uses differential gearing, eliminating the use of clutches. A standard, but



midget relay is built into the device to provide various load combinations, including double pole, double throw. —*Ward Leonard Electric Co., Mount Vernon, N. Y.*

## Rheostat

Designed for plate circuit tone control and other similar applications, a new metallized type "Power Control" capable of carrying 2 watts, known as the IRC Type C P Control, incorporates the features and possesses the characteristics of the "Type C Control," including metallized type resistance element permanently bonded to a moisture-proof Bakelite base,

5-finger contact, etc. Rapid heat conduction from element to cover and shaft assembly, obtained by arrangement of a copper heat conducting plate, makes possible conservative 2 watt rating as compared to the ½-watt rating of standard IRC Type C Controls. Size is the same as that of the latter, said to be unusually small for a power control of this rating. —*International Resistance Company, 401 North Broad Street, Philadelphia, Pa.*

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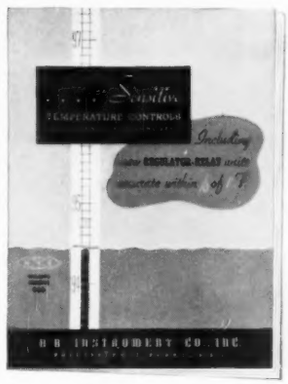


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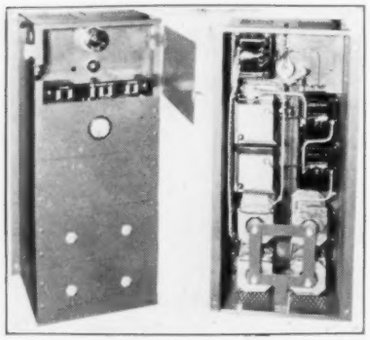
## Battery Eliminator

Many devices better suited to the use of direct current, such as signaling systems, private telephones, impulse clocks, bells, fire alarms. For them batteries and charging equipment, or some form of rectifier has been necessary. The Recti-FilteR, uses disc-type copper-oxide rec-



tifying units which are quiet, motionless, and require not as much maintenance as a lamp bulb. Alternating current is simply plugged into one end and out comes direct current from the other. The rectifier units are made in various sizes, determined by the output current and voltage requirements.—*Raytheon Mfg. Co., Electrical Equipment Div., 124 Willow St., Waltham, Mass.*

## Voltage Divider Components

Sectional units, and a mounting base of the required length to accommodate them, make it possible to assemble voltage dividers to meet varied needs. Each "Series BYO" (Build-Your-Own) unit is a complete molded-seal metal-clad resistor with two terminals of the required ohmage for that section. Bakelite-encased winding construction is used. Units slide into and fit snugly in the base mounting strip which takes the requisite number of units. Adjacent terminals are connected together to form a single resistance network of all the sections, or the sections may be used individually since they are normally insulated from one another.—*Clarostat Mfg. Co., Inc., 285-7 N. Sixth St., Brooklyn, N. Y.*

## Penetrometer or Hardness Tester

New "Model 1122" Hardness Testing Gage was developed for the rubber industry: after having been originally designed, it was tried out under plant conditions, brought back and changed to conform with the requirements which appeared necessary when in use. It conforms to ASTM standards and can be adapted to other standards. One of its principal features is that irregular surface of sample is first pressed down under a known weight, and platen locked into position. Penetrometer point is then allowed to settle into the rubber under a known constant weight and the penetration read after a definite time. Levers operate automatically so that operation is simple and fool-proof. Instrument can be installed so that intermittent tests can be made of a sheet of rubber as it is being run off. It is chrome-plated so that it may be easily cleaned of the soap stone and talcum powders used in the rubber industry. — *Federal Products Corp., 1144 Eddy St., Providence, R. I.*

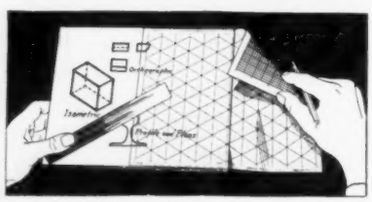
## Binocular Head Magnifier

This magnifier, which will be of value to inspectors, tool setters, pattern makers and others who do delicate work, is worn on an adjustable, elastic and flexible head band and can be used for long periods without discomfort. It magnifies 2¼ times. This is ample for fine work, for as a rule a large field of view (up to 7

inches diameter) and a long working distance (up to 8 inches) are just as important as magnification. The magnifying lenses are made prismatic, and lie in one plane. A deep light screen of black bakelite excludes any disturbing stray light.—*George Scherr Co., 120 Lafayette Street, New York, N. Y.*

## Sketch Pad Set

Intended for making any type of sketch to any scale, this set consists of a pad of tracing paper; a cellulose covered buff guide plate that slides under the top sheet of the pad, and is printed in blue ink showing ⅛" squares, every ½" line heavy and every 1" line numbered; and on the other side an isometric design with all three axes divided 1", ½" and



¼" so that drawings showing all six sides and interior may be made to any scale. Made in pads 200 sheets 5½"×8½"; 100 sheets 8½"×11"; 50 sheets 11"×17".—*Wade Instrument Co., 1663 East 118th Street, Cleveland, Ohio.*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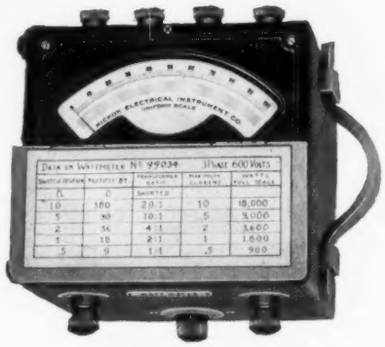

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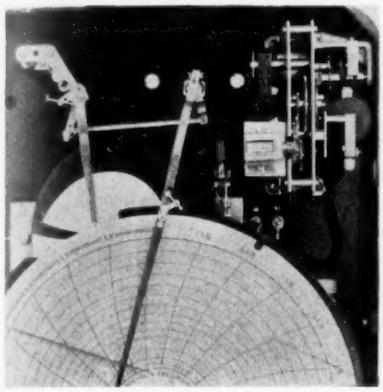
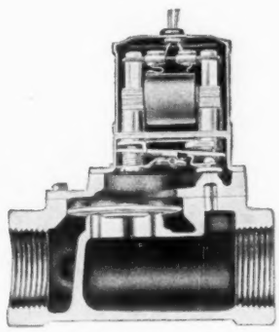
## Flow Integrator

Maker's mechanical and electric flow meters, for measuring the flow "of a gas or non-viscous liquid through a closed line," are now equipped with a new electric integrator which totalizes flow once every 15 seconds. A flat disk cam, shown in the figure partially concealed by the chart plate of the instrument, is so designed that, at 15-second intervals, it mechanically computes the square root of the differential pressure across an orifice plate or Venturi tube primary element in a pipe line. The values obtained are totalized and indicated on a six-digit cyclometer register. Integrating mechanism (shown to upper right of cam) consists essentially of a continuously running Telechron motor, operating a counter through a train of gears which are engaged and disengaged by means of a mercury switch and magnet. Cam rider, connected through a link to recorder pen arm, operates mercury switch in one direction while on cam and allows it to return to its original position when off cam. In latter position, magnet is energized so that gears are meshed and integrator is totalizing. Thus, while Telechron motor runs continuously, it operates totalizer counter only when gears through integrator are meshed.—*The Bristol Co., Waterbury, Conn.*



## Magnetic Gas Valve

The new Friez Magnetic Gas Valve is suitable for every type of gas burning boiler, furnace, or stove, or for industrial uses. It is also suitable for use with such equipment as gas fired humidifying equipment, etc. This new valve requires no attention, and operates with entire safety on low voltage (6 V.) without hum or noise. The illustration shows a standard valve in the closed position. The function of the valve can best be visualized as a valve of the diaphragm type with the diaphragm cut loose from its housing, and made in the form of a small floating disc, which disc floats loosely in the chamber. In the closed position the incoming gas leaks through the clearance around the circumference of the disc filling the upper chamber with gas at line pressure. As the gas cannot escape through the bleeder the pressure holds the disc firmly on its seat, as there is only atmospheric pressure below the disc. When the control instrument through the electromagnet, lifts the bleeder valve, the pressure above the disc is immediately released to the down stream side. The incoming gas then lifts the floating disc to the top of the chamber, and as long as the bleeder valve is open it is held up, (1) by the differential of pressure above and below the disc, (2) by the impact pressure from the gas line, and (3) the wiping effect of the gas flowing around the edges of the floating disc. It will be noted that the bleed gas joins the downstream flow in the valve itself, it being unnecessary for the bleed gas to be fed into the burner, as is the case with the usual type of diaphragm valve. When the control instrument is satisfied and the electrical circuit is broken, the relay closes the small bleeder valve. The flow momentarily continues around the circumference of the floating disc until the pressure in the chamber above the disc equals line pressure, and the disc is then forced down on its seat. The closing process occurs in a fraction of a second.—*Julien P. Friez & Sons, Inc., Baltimore, Md.*

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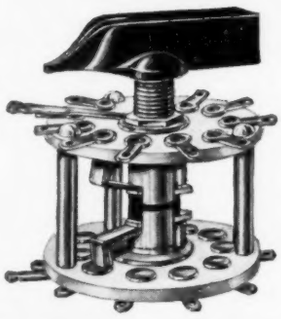

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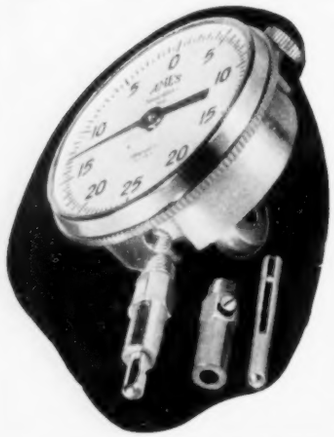

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Carriage mounts: ball-bearing;
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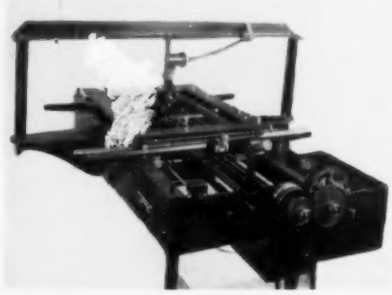
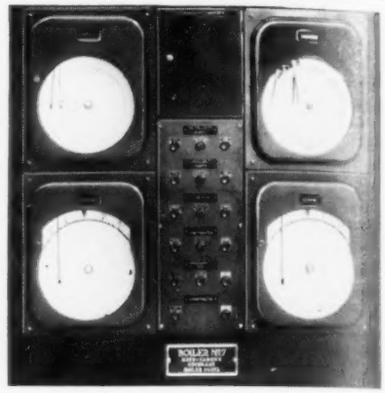
Instrument can be furnished as a plate measuring device with microscope underneath carriage, or with an overhead microscope. Microscope uses standard objectives. Basic machine can be used as a conventional single-coördinate comparator; cross slide can be furnished with a screw to convert device into a two-coördinate comparator of extreme range, or it can also be used as the basis of a microdensitometer either visual or recording. Can be furnished with either English or metric screws. English screws are 20 threads per inch with dials reading directly to 0.0001". Automatic features of the microdensitometer designs are specially built to meet particular demands.—*Micro Instrument Co., Cambridge, Mass.*



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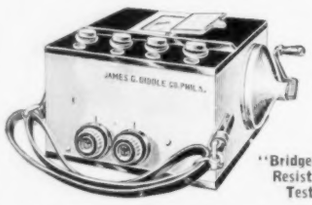

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in to read 10 megohms with external battery. A-c. voltmeter usable as output meter using same scale as a-c. volts. Instrument is guaranteed within 2% accuracy on all ranges. Adjustment can be made for changes in rectifier efficiency. Panel is engraved Bakelite, steel case measures 7"×4½"×3⅛". Unit is complete, self-contained, with rheostat to adjust instrument to batteries outside. Four-foot leads.—*The Hickok Electrical Instrument Co., Cleveland, Ohio.*

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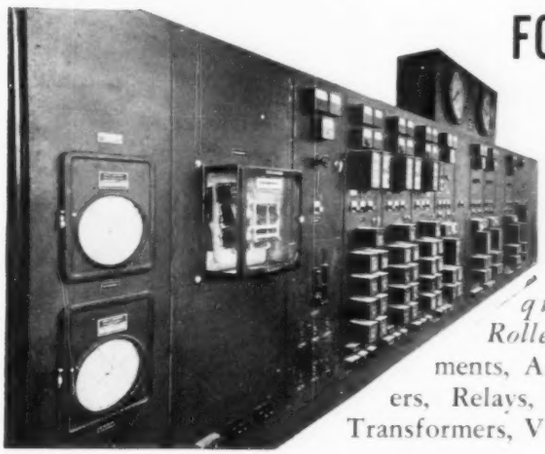

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# Twin Control for Warm Air Furnaces

Streamlining of automatic heating and air conditioning units is said to have influenced development of new "Type M-80" Combination Fan and Temperature Limit Control for warm air furnaces (Fig. 1). Enclosed in one case, it has double adjustments for both fan and limit switch settings. These adjustments permit individual setting of both "high" and "low" operating points. Range can be adjusted over entire scale. Differential can be set for close operation or

Fig. 1

widened to meet any field requirements. A dial thermometer indicates from 50 to 300°F. New combination embodies the elements of the "M-51" warm air furnace control to open the electric circuit automatically and thus acts as a safety limit control to prevent overheating. It also incorporates features of the "M-53" fan control which prevents blowing of cold air into room if furnace is not hot enough. On average installation, control is set to operate fan when furnace is 150° or higher and stop fan when temperature is 120° or less. This setting can be varied. Safety and ease-of-adjustment features in the M-80 Twin Unit include the following: Within case, a non-conducting shield prevents any contacts with "hot" wires when adjustments are made.

Fig. 2

An adjustable flange facilitates installation on furnace hood, being adjustable for any angle between 30° and 90°. For flat surfaces a 90° permanent flange is furnished. Mercoid sealed mercury switch (Fig. 2) operating medium. Inert gases are said to stifle the arc instantly so that there can be no arcing, oxidation or corrosion.—*Mercoid Corporation, 4201 Belmont Ave., Chicago, Ill.*


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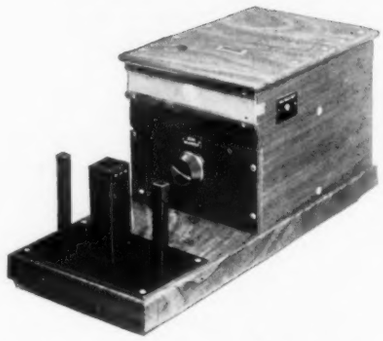
# Coil Tester



This instrument will detect the presence of one or more shorted turns in a coil regardless of the total number of turns or size of wire in the coil. Test is performed at 60 cycles using induction method which requires no electrical contact. Used by leading makers and users of coils.

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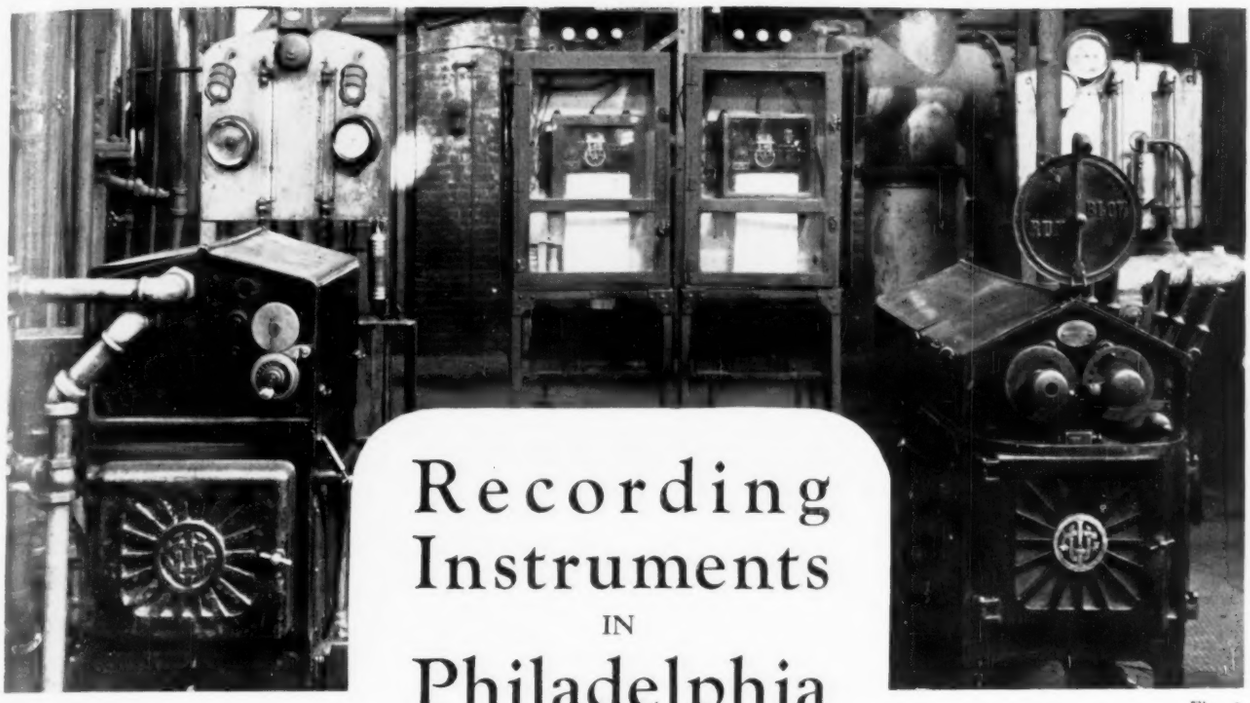

Fig. 1

# Recording Instruments IN Philadelphia Gas Manufacture

By WALTON FORSTALL, Jr.
Engineering Assistant, The Philadelphia Gas Works Company, Philadelphia, Pa.

GAS is nowadays used almost exclusively as a fuel. In practically all its applications, from domestic cooking to the most sensitive heat-treating processes, the maintenance of uniform conditions is of greatest importance. An important factor in the control of processing conditions is uniformity of the fuel itself.

Gaseous fuel has great potential advantages over other fuels by reason of the ease with which combustion can be controlled. The qualifications of gas, which are important factors in the preservation of uniform combustion conditions and must therefore be kept uniform for best service, are: (1) Calorific value, (2) Burning characteristics, (3) Density, and (4) Pressure at which it is supplied to the burners.

The part which recording and telemetering instruments play in the production and distribution of a gas of practically uniform quality in the above respects is recounted in this article. The practice in one large manufacturing plant is described as typical.

## TEMPERATURE MEASUREMENT

In the early days of water gas manufacture, gasmakers were forced to regulate the temperature of the set by intelligent guesswork. In consequence, the oil was frequently over- or under-cracked, resulting in the production of gas and tar of such an uncertain and variable nature that the final cost of maintaining a given standard of quality was higher than it would have been with proper temperature control.

In an effort to assist the operators in estimating heats by eye, the United Gas Improvement Co. developed in 1902 the so-called "blue glass pyrometer." This adaptation of the extinction type of optical pyrometer was simply a series of glasses of graded densities which the operator could interpose successively between his eye and the heated surface. The glass by which vision was first completely obscured was a measure of the temperature.

This method was not satisfactory in practice because the density of glass required to obscure the radiant object depended not only upon the temperature but also upon the characteristics of the operator's eye, which, of course, varied with the individual. Even with the same observer, since the instrument was not designed to exclude light from the room, results were altered by differing conditions of general illumination which caused varying degrees of dilation of the pupil.

About 1905, experiments were conducted with a rare metal thermocouple and a d'Arsonval galvanometer. Although the possibilities of this method were thoroughly explored, the delicacy of the galvanometer precluded its use in the generator house as an operating instrument. A base-metal thermocouple connected to a milliammeter graduated in degrees Fahrenheit was the next development. It proved reasonably satisfactory, but had the fundamental shortcoming that it was only an indicating instrument: there was still no easy way of determining whether the heats were ascending, descending, or stationary. The recording pyrometer was eagerly welcomed as it became available, although the early ones were much affected by changes in the resistance of the external circuit due to varying room temperature and faulty joints. With the development and constant improvement of the potentiometer recorder, however, all essential difficulties have been overcome so that now, with a thermocouple inserted in the super-heater and a recording unit mounted near the controls, a gasmaker knows both the temperature and the temperature trend of each set and can, as it becomes necessary, alter his operating conditions intelligently. Fig. 1 shows the pyrometers and controls for two adjacent water gas sets at the Point Breeze Plant of the Philadelphia Gas Works Company.

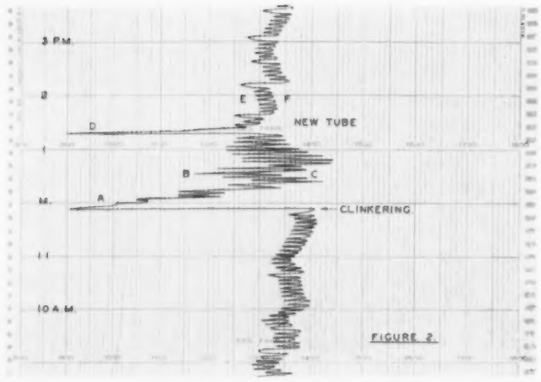

FIGURE 2.

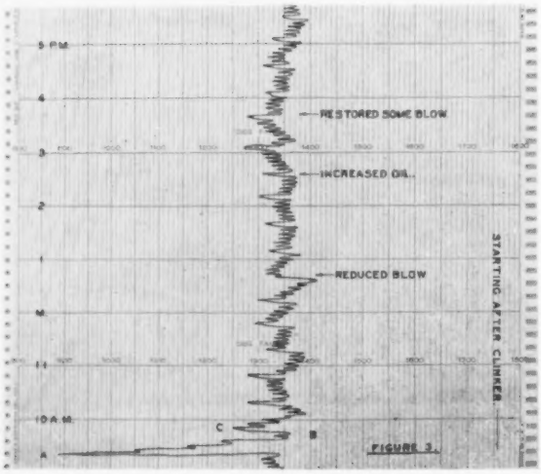

FIGURE 3.

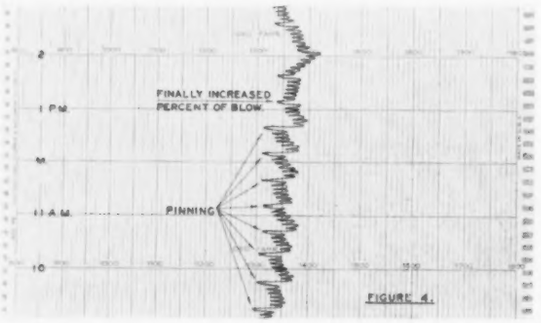

FIGURE 4.

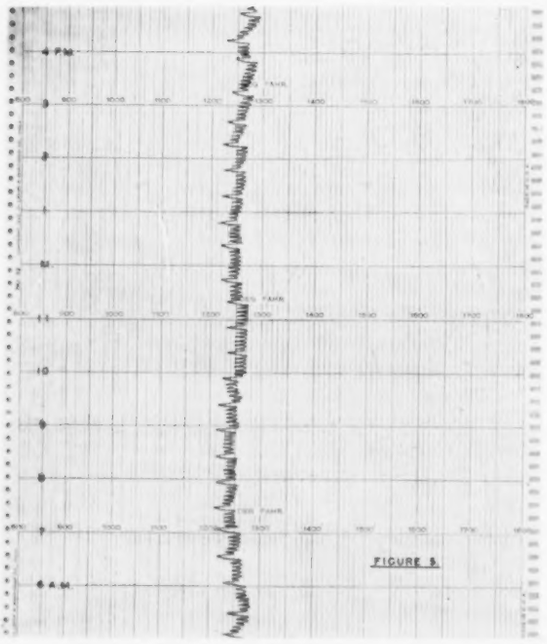

FIGURE 5.

In addition to furnishing immediate control information, the recorder chart serves as a record of set operation, since almost every manipulation of controls is reflected in a change in temperature and hence is represented on the temperature record. The manufacture of water gas is a cyclical operation, in which the gas making period or "run" absorbs heat from the set, necessitating a combustion or "blow" period to restore it. These alternations in temperature are clearly seen in Figs. 2, 3, 4 and 5. Control of the set is based upon an optimum median temperature. The variation between maximum and minimum is really much greater than that indicated by the recorder, for since the median temperature is all that is desired, the thermocouple is well protected from direct heat by enclosure in a piece of iron pipe of triple thickness projecting into the superheater. The pipe lasts about 90 days before burning out, an occurrence shown in the temperature chart reproduced in Fig. 2. When the set was started after clinkering (*A*), the wide swinging (*B* to *C*) of the recorder pen indicated a sensitivity not desirable. Investigation disclosed that the old protecting tube had burned out; a new one was installed (*D*), and the variation was reduced to normal (*E*-*F*).

Fig. 3 shows the normal starting operation of a water gas set after shut-down for clinkering. This set was started (*A*) about 9:30 a.m., coming up rapidly to the desired temperature of 1350° F. At about 9:45 a.m. the generator lid was opened to fuel (*B*). During the operation the set lost heat, which was quickly regained when gas making was resumed (*C*). These reductions in temperature due to fueling every half-hour are clearly seen at approximately 10:20, 10:50, 11:20, etc. By 12:30 the temperature was beginning to build up rapidly, so the assistant foreman reduced the blow period and the temperature settled down nicely to the 1350° average he was trying to hold. About 2:30 p.m. an increase in the amount of carburetting oil caused the temperature to slope downward. By 3:30 p.m. this tendency was quite pronounced, the blow period was increased, and the heats began to climb.

Fig. 4 shows an example of poor set operation. The trend of heats was downward but the gasmaker, instead of increasing the percentage of blow, brought the set back up to heat after each coaling by one abnormally long blow. This practice is known as "pinning" because it is accomplished by holding out the driving pin of the automatic cyclical machinery* while it is in the blow position. In contrast, observe the rather remarkable operation pictured in Fig. 5, showing eight hours during which, by constant watchfulness and skillful adjustment, the median temperature was held close to 1250° throughout all the varying conditions of the shift.

## CALORIMETRY

Perhaps the most vital and interesting application of recording instruments in operating control of a gas plant is the use of recording calorimeters. The agreement between the City of Philadelphia and the Philadelphia Gas Works Company calls for

> . . . a daily average total heating value of not less than 530 and not more than 560 British thermal units per cubic foot of gas when measured at a temperature of 60 degrees Fahrenheit and a pressure of 30 inches of mercury.

It would be possible, of course, to allow the heating value to vary above and below 530 B.t.u./ft.$^3$ in such a manner that the daily average equaled or was greater than 530. It would not be good service.

Commercial gas made at the Point Breeze plant is a mixture of four components: (*a*) carburetted water gas, (*b*) refinery oil gas, (*c*) coal gas, and (*d*) coke oven gas. These must be mixed in accordance with the physical properties of each in such a way that the product is relatively uniform in

*This machinery represents an interesting application of Instrumentation principles but its function does not come within the scope of this article.

calorific power and density. Here the beautiful flexibility of the water gas process may be appreciated, for it is possible to vary its heating value from 250 to 700 B.t.u./ft.$^3$. The Point Breeze plant buys its oil gas and coke oven gas, and is bound to take a fixed quantity of each. The rate at which coal gas is made is practically constant because the process is a slow roasting of coal, yet its density and calorific power vary somewhat from hour to hour, being noticeably affected by drawing and charging of the retorts. This leaves water gas as the only factor in the mixture capable of complete flexibility in quantity and quality. Its control must be based on a knowledge of the state of each of the other three gases and the trend of the mixture. To this end, samples of each gas and of the mixture in its various stages are piped to a small test building where the density recorders and calorimeters (among other instruments) are housed. Fig. 6 is a view inside this building. Prominent at the left is the work-stand for Hinman-Junker calorimeters—indicating instruments only. In the basement are the tank units of eight Cutler-Hammer Thomas calorimeters, of which only four can be seen in the photograph, Fig. 7. The recording units (Fig. 8) stand in the plant valve room, where their readings are available continually for the control of plant operation.

The Company strives to maintain a daily average of 532 B.t.u./ft.$^3$ with no readings less than 530. To keep within this narrow margin under all operating conditions, the production of water gas must be *at all times* so guided as to effect the following: the water gas (*a*) to have such a heating value that when it is mixed with (*b*) oil gas that varies between 1700 and 1800, (*c*) coal gas that varies from 450 to 500, and (*d*) oven gas that varies between 525 and 540, the product will contain just 532 B.t.u./ft.$^3$. That this is possible is due to accurate information supplied by the Thomas calorimeters combined with skillful plant operation that comes from many years of experience.

In the Thomas calorimeter the gas, combustion air, and heat-absorbing air are supplied in constant ratio by means of wet meters geared together and driven by an electric motor. By reason of efficient heat transfer, the temperature rise of the heat-absorbing air is proportional to the total heating value of the gas. This differential is continuously measured by means of inlet and outlet thermometers of the nickel resistance type and charted on a Leeds & Northrup potentiometer recorder calibrated in B.t.u./ft.$^3$. Jessup* declares that "the Thomas calorimeter can be used to measure total heating value of gases with an accuracy well within one percent provided the calorimeter is given the necessary care and the heating value of the gas does not vary rapidly." That this is a conservative opinion the records of the Philadelphia Gas Works Company amply prove: from more than five years' operating experience it appears that the Thomas calorimeter under the best care records to ∓2 B.t.u. on gas of 530 B.t.u.—an accuracy of three-eighths of one percent.

Once each day all the Thomas calorimeters are put on commercial gas and the heating value checked by means of a Hinman-Junker calorimeter, using thermometers calibrated by the National Bureau of Standards and weights certified by the Inspector of Weights and Measures of the City of Philadelphia. Table I shows the agreement between the Thomas and the Hinman-Junker for a period of two weeks.

In order that the gas as it reaches the consumer may be examined, there is a testing station one mile from the works, taking its sample gas from the distribution system. Here the heating value is measured with a Thomas calorimeter supplemented by hourly readings from a Hinman-Junker. One day's readings are given in Table II.

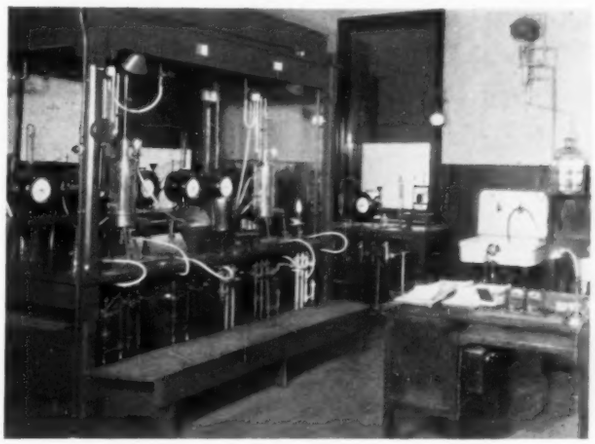

Fig. 6. Calorimetry Building

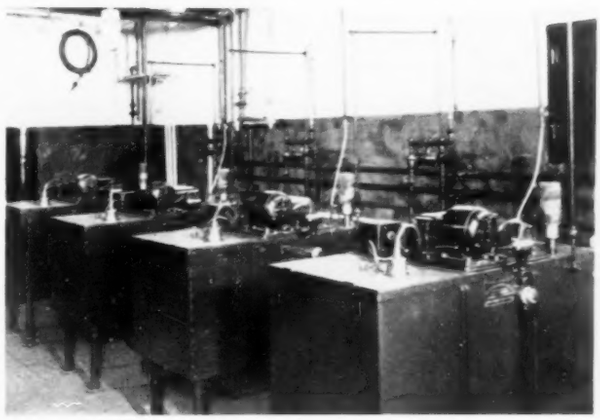

Fig. 7. Basement of Calorimetry Building

Fig. 8. Valve Room, The Philadelphia Gas Works Co.

*For a complete description and analysis of the capabilities of the Thomas calorimeter, see R. S. Jessup: The Thomas Recording Gas Calorimeter, *Bureau of Standards Journal of Research*, Vol. 10, January 1933, Research Paper No. 519.

TABLE I

Daily check of the Thomas recording calorimeter with heating value obtained from a Hinman-Junker calorimeter, both instruments being on commercial gas at the Point Breeze plant of the Philadelphia Gas Works Company. This record is for the first half of September, 1936.

| *Day* | *Thomas* | *Hinman-Junker* | *Difference* |
|---|---|---|---|
| 1 | 531 | 531 | 0 |
| 2 | 532 | 532 | 0 |
| 3 | 532 | 531 | 1 |
| 4 | 531 | 530 | 1 |
| 5 | 531 | 534 | 1 |
| 6 | 531 | 531 | 0 |
| 7 | 533 | 532 | 1 |
| 8 | 532 | 531 | 1 |
| 9 | 534 | 533 | 1 |
| 10 | 532 | 533 | — 1 |
| 11 | 533 | 532 | 1 |
| 12 | 532 | 532 | 0 |
| 13 | 531 | 531 | 0 |
| 14 | 532 | 532 | 1 |
| 15 | 531 | 531 | 0 |
| Average | 532 | 532 | |

TABLE II

Hourly check of Thomas recording calorimeter against Hinman-Junker calorimeter, both on distribution gas at City Test Station, one mile from Point Breeze Plant. Sept. 1, 1936.

| *Hour* | *Thomas* | *Hinman-Junker* | *Difference* |
|---|---|---|---|
| 7 a.m. | 534 | 533 | 1 |
| 8 | 531 | 532 | 0 |
| 9 | 531 | 532 | — 1 |
| 10 | 532 | 532 | 0 |
| 11 | 531 | 531 | 0 |
| 12 | 532 | 531 | 1 |
| 1 p.m. | 532 | 531 | 1 |
| 2 | 532 | 532 | 0 |
| 3 | 532 | 531 | 1 |
| 4 | 532 | 531 | 1 |
| 5 | 532 | 532 | 0 |
| 6 | 532 | 532 | 0 |
| 7 | 532 | 531 | 1 |
| 8 | 531 | 531 | 0 |
| 9 | 532 | 531 | 1 |
| 10 | 532 | 532 | 0 |
| 11 | 532 | 532 | 0 |
| 12 | 532 | 531 | 1 |
| 1 a.m. | 532 | 531 | 1 |
| 2 | 532 | 532 | 0 |
| 3 | 532 | 531 | 1 |
| 4 | 532 | 531 | 1 |
| 5 | 532 | 532 | 0 |
| 6 | 532 | 532 | 0 |
| Average | 532 | 532 | |

TABLE III

Monthly figures, showing heating value control from records of City Test Station, one mile from Point Breeze plant of The Philadelphia Gas Works Company, for the year 1935. Since they are taken hourly, from a Thomas recording calorimeter, the number of readings corresponds to the number of hours in each month. The average heating value given is the average of these readings.

| *Month* | *No. of Readings* | *Number under 530* | *Average Heating Value* |
|---|---|---|---|
| Jan. | 744 | 2 | 532 |
| Feb. | 672 | 0 | 532 |
| Mar. | 744 | 0 | 532 |
| Apr. | 719 | 0 | 532 |
| May | 744 | 1 | 532 |
| June | 720 | 4 | 533 |
| July | 744 | 0 | 532 |
| Aug. | 744 | 4 | 533 |
| Sept. | 721 | 0 | 533 |
| Oct. | 744 | 0 | 532 |
| Nov. | 720 | 0 | 532 |
| Dec. | 744 | 1 | 532 |
| Total | 8760 | 12 | Avg. 532 |

Fig. 9 is a reproduction of some of the Thomas calorimeter charts for September 1, 1936. The day was chosen at random and the charts are typical. The two chart sections at the left show a continuous record of the heating value of oil gas and coal gas. When these two gases are mixed with the controlling water gas the result is a heating value shown by the third record from the left. The heating value of the oven gas is given in the fourth record. When this gas is mixed with the other three the mingled gases pass to storage. At the inlet to the holders a sample is taken and produces the fifth record, labeled "Inlet." Further mixing with previously manufactured gas in the storage holders smooths out the variation to produce the sixth record, marked "Test," which is the gas as it passes through the mains, this chart being made at the City testing station. Table III gives the figures for heating value control for the year 1935.

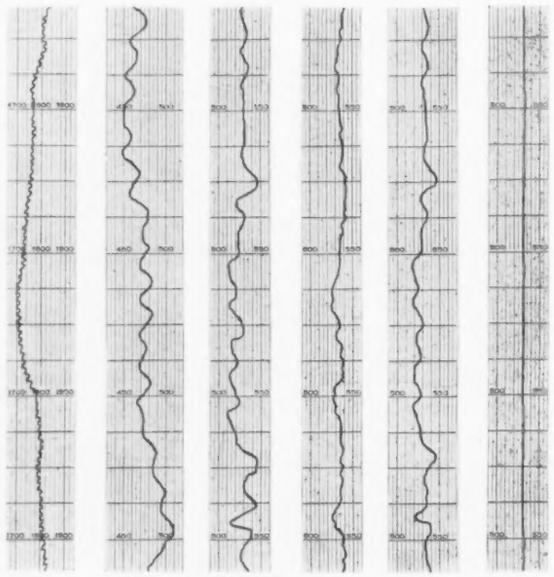


Fig. 9

### GRAVITOMETRY

Years ago, prior to the use of the Bunsen burner, little or no attention was paid to density of gas as a property important to the consumer. Even though candle-power varied with gas input, and hence density, in the days of the candle-power standard and the flat luminous flame burner, the effect of density was negligible compared to that of pressure. Today, however, gas is used almost entirely for its heating effect. Pressures and heating value are specified carefully by regulatory bodies and are closely controlled. Variation in density manifests itself at the burner in two ways—changes in heat input and changes in the character of the flame—of which the second is the more important. At any given pressure, as the gas becomes heavier the rate of flow becomes less, decreasing heat input slightly. At the same time more air is entrained in the mixer so that the air-gas ratio increases and the flame becomes harder and approaches the possibility of flashback. As the gas becomes lighter the rate of flow and heat input increase. Less air is drawn in so that the air-gas ratio decreases, the flame becomes softer and approaches the point of incomplete combustion.

In controlling the specific gravity of commercial gas within certain permissible limits, advantage is again taken of the flexibility of the water gas process. Within the range of water gas heating values required by normal operation of the Point Breeze plant, it is possible to vary the specific gravity of water gas between 0.66 and 0.72 with little change in heating value. Thus the density of this mixture of four gases, commerical gas, can be controlled by regulation of the water gas gravity.

In the maintenance of uniform density, Ranarex recorders play the same part as do the Thomas calorimeters in maintenance of uniform heating value. A Ranarex recorder on each gas and on the mixture in its various stages is the source of test information needed for accurate control by the water gas generator house foreman. This instrument, by balancing the density effects of test gas and of air under atmospheric conditions as they exist at the moment, obviates the need of correcting for barometer and dew point, since gas and air are about similarly affected by changes in barometric pressure and humidity. In the Ranarex recorder (see *Instruments,* November 1931, page 623), two cylindrical chambers are provided, one for gas and one for air, each with a motor-driven rotary impeller at one end and a set of stationary vanes at the other. The impellers turn with equal speed but in opposite directions. As the test gas passes through its impeller, it is given a whirling motion clockwise, thus imparting a clockwise torque to the vanes at the other end of the gas chamber. Similarly, air is whirled and imparts a counter-clockwise torque to the air chamber vanes. These torques differ by a value proportional to the differ-

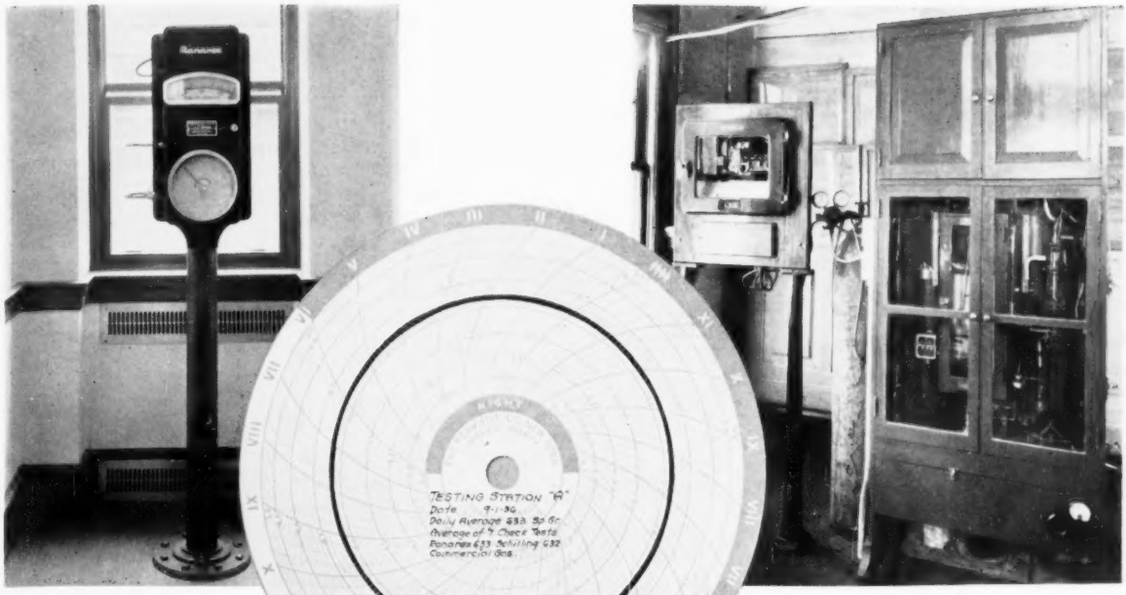

Fig. 10. Indicator-recorder for density of commercial gas.

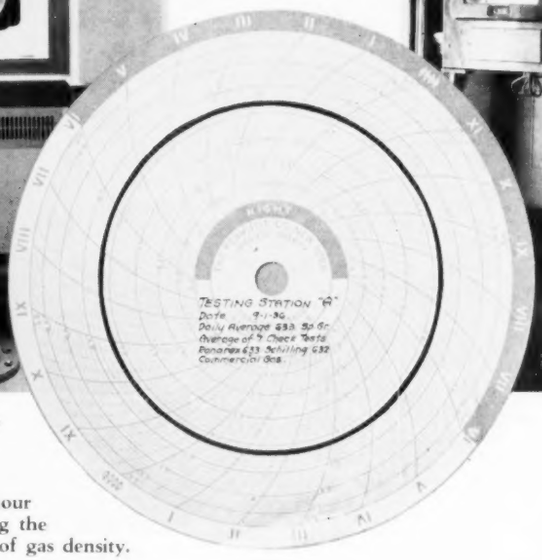


Fig. 11. 24-hour chart showing the maintenance of gas density.



Fig. 12. Automatic analysis apparatus for continuously recording the nitric oxide content of commercial gas.

ence in the gas and air densities. The vanes are interconnected and the differential torque is transferred to a pointer which indicates specific gravity, air being taken as unity. The pointer extends into a pen-arm which traces a continuous record on a circular chart. The Ranarex recorder in use at the City test station is shown in Fig. 10. Fig. 11 shows its chart for September 1, 1936. Though the gravity of commercial gas is kept nicely constant from hour to hour, it does vary between a high of 0.68 in winter and a low of 0.53 in summer. This is due to the fact that the proportion of water gas to the mixture is far greater in winter with the larger send-out and water gas can be made most economically with a gravity about 0.70.

Once each day the Ranarex recorders are checked by operation on air for a brief period. In addition, a determination of the specific gravity of the test gases is made daily with the Schilling effusion apparatus, in the use of which equal quantities of test gas and of air escape through a fixed orifice under similar conditions of temperature and pressure, and the respective time intervals are taken with a stopwatch. Specific gravity of test gas referred to air is approximately equal to the direct ratio of the squares of these effusion intervals. Any large discrepancy between the Schilling value and the Ranarex value would be a matter for investigation.

### NITRIC OXIDE DETERMINATION

Knowledge of the quantity of nitric oxide contained in commercial gas is helpful in reducing gum formation in the controls of the modern gas appliance. Continuous analysis of gas for nitric oxide is accomplished by the recorder described in detail in an article by W. E. Stackhouse in *Instruments* for June, 1936. The principle involved is the comparison of color imparted to Griess reagent by a measured volume of gas with that produced by a known volume of standard nitrite solution. A photograph of the apparatus is shown in Fig. 12.

### PRESSURE TELEMETERING

Since pressure at any given point in a distribution system varies with load and must be regulated by altering conditions at the source, it is evident that it is the distant pressure that should be the control information for plant and holder stations. The Kennedy Telemetric Gage, designed to supply this information, is an impulse-counting type of electrical telemetering system (see *Instruments*, January 1936, pages 11-15). Its transmitter consists of a liquid-seal pressure gage, in which a float is used to measure the height of the atmospheric leg. Change in position of the float causes a spring-driven electric telegraph to send out impulses corresponding to the new level and hence to the new pressure. An indicating needle at the receiving end is moved to its proper position by these impulses. If it is desirable, more than one indicator may be used at widely distant points from the same transmitter.

The Point Breeze plant supplies much of its share of the City load through high-pressure transmission mains. It is also, however, a low-pressure distribution point for a large area surrounding the plant. If the station governor outlet pressure were kept constant, the outlying sections of this area would suffer a drop in pressure with peak loads. So the governor outlet pressure is regulated according to the pressure existing at a selected point more than two miles from the works, where it is desired to maintain 4.6″ of water. To maintain it during the night 5.2″ is all that is needed at the governor but during the peak load the governor must be weighted for 8.0″. Within this range, weights are added or removed as the telemetric gage shows a variation from 4.6″ at the distant point.

This article has necessarily been limited to the more important applications of recording and telemetering instruments to the process of gas manufacture. Needless to say, many other tests and observations are being made continually.

# Early Scratch Hardness Methods

Eighth instalment of "Hardness and Hardness Measurements." See page 1, Jan. 1937 issue.

By S. R. WILLIAMS
Professor of Physics, Amherst College

While Mohs' scale of hardness has proved to be of value to the mineralogist, it has little value in measuring the hardness of different varieties of glass. This was brought out by Auerbach[13] in investigating the relations between hardness and other elastic properties. He found that the softest glasses would scratch the hardest samples. The investigation was carried out on a group of 14 different grades of Jena glass whose hardness ranged in ratios as high as 1:2. It developed from Auerbach's work that Mohs' scale of hardness must be abandoned as a measure of the relative hardness of the glasses and go over to a procedure in which attention was paid to the degree of scratching. This was rendered difficult by the fact that under the microscope the character of the scratch was quite different from the various samples.

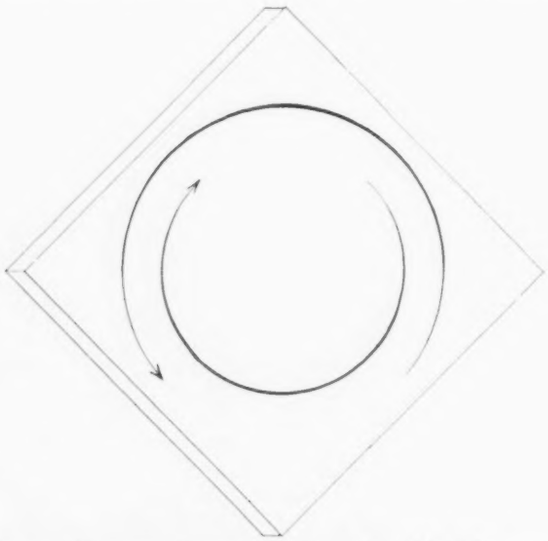

**Fig. 42. The curved arrows show by their width differences in hardness as the diamond point is moved over the surface of a calcspar crystal, either against or with slip planes.**

Some scratches appeared to have leaves attached to them, others expanded and contracted like a model of muscle structure and still others were to be differentiated by transverse and longitudinal characteristics.

When Auerbach came to compare two kinds of glasses, each one of which scratched the other, it became necessary to study microscopically which one of the two scratches was the most pronounced. In this fashion he was able to classify the various grades of glass according to their scratch hardness. On comparing the scratch hardness with the indentation hardness, Auerbach found a rough correlation for most of the samples, but not for all. The scratch method gave such misleading results that Auerbach declared it unsuited for scientific investigation.

At this point it would not be out of place to emphasize once more that glass is a homogeneous vitreous mass, wherein one is not dealing with crystal structures as the mineralogists are. Even the scratch method, when applied to crystals, is by no means perfect, as Grailich and Pekárek[14] have pointed out. The hardness of an Iceland spar crystal depends on the face and the direction in which the scratching point is drawn. This goes back to the old story of brittleness and plasticity. Scratches cross-wise to slip planes should be more brittle. Fig. 42 shows how the hardness varies over the surface of a calcspar crystal. These authors state that the term "hard," as used by the earlier paleontologists and mineralogists, was decidedly unscientific, and refer to several investigations in corroboration of this idea.

Auerbach's work pointed the way to improvements in the scratch method. This consisted in providing devices whereby hand pressure could be replaced by uniform pressure either by a sliding weight or by a spring. The new improvements provided for means whereby the substance could be moved at a uniform rate under the fixed

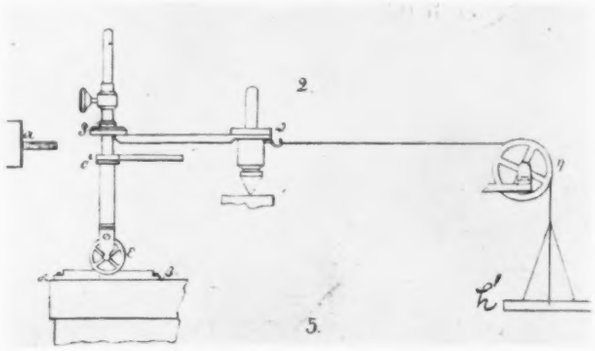


**Fig. 43. In this arrangement of diamond point the specimen remains stationary and the diamond point moves over the surface. A load on *b'* moves the diamond point along.**

scratch stylus or else the stylus moved uniformly over the fixed surface. Microscopes were added so that width, depth and general character of the scratch could be minutely studied and measured. The various types of sclerometers developed along these lines are legions. Reaumer, 1733, and Pansner, 1813, are among the earliest to use a scratch method. Pansner used a series of diamond and steel points with which to scratch his materials. Frankenheim used metal needles and judged relative degrees of hardness by the pressure and pull necessary to produce a scratch.

Franz[15] starts off his investigation by defining hardness: "It appears to me," he says, "that the hardness of minerals consists in the resistance to separation of the particles composing the body . . . Hardness is that force to be found in minerals which prevents the penetration of a body into a crystal." Franz had two different arrangements for a relative movement between the diamond point and the surface to be scratched: (1) The diamond point and its carriage was moved while the specimen was held in a fixed position. The mechanism for this movement is shown in Fig. 43. Masses were

[13] F. Auerbach. Ueber die Härte- und Elastizitätsverhältnisse des Glases. *Annalen der Physik und Chemie*, Vol. 53, 1894, pages 1000-1038.

[14] J. O. Grailich und F. Pekarek. Das Sklerometer, ein Apparat zu genaueren Messung der Härte der Krystalle. *Sitzungsberichte der mathematisch-naturwissenschaftlichen Klasse der kaiserlichen Akademie der Wissenschaften, Wien*, Vol. 13, 1854, pages 410-436.

[15] R. Franz. Ueber die Härte der Mineralien und ein neues Verfahren dieselbe zu messen. *Annalen der Physik und Chemie*, Vol. 80, 1850, pages 37-53.

added to the scale pan $h'$ until the diamond moved with even motion across the crystal. (2) The crystal was moved beneath the diamond point while the latter was held stationary. The load on the diamond point could be varied by changing the masses applied to the scale pan $p$. Fig. 44 shows this arrangement. The screw $f$ actuated the movement of the table which carried the crystal.

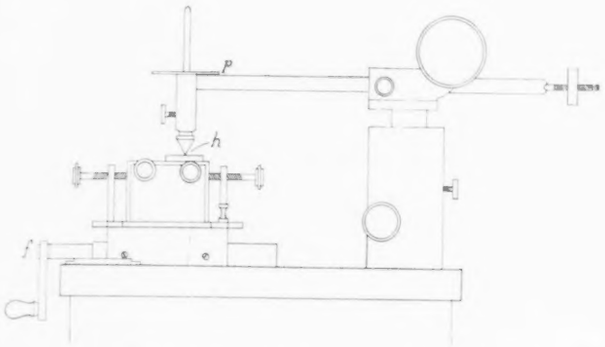


Fig. 44. Franz's instrument for measuring hardness by the scratch method. By means of the screw $f$ the specimen moves under the stationary diamond point $b$.

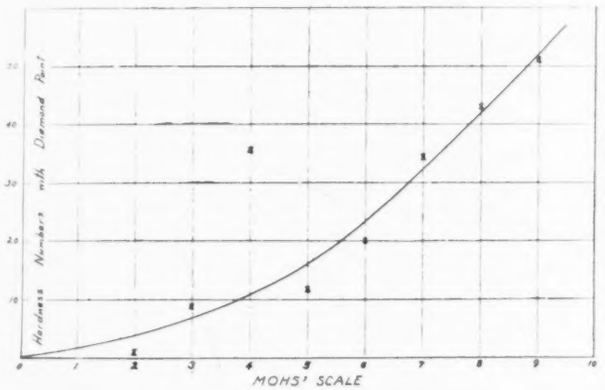


Fig. 45. Mohs' crystals as measured by Franz's scratch-hardness tester.

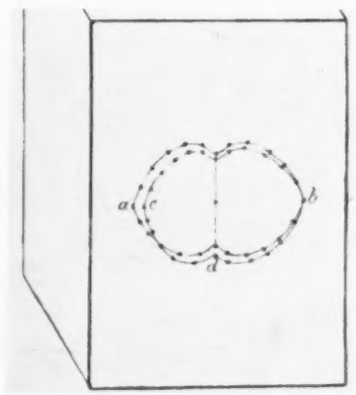


Fig. 46. Lines of equal hardness on the face of a cyanite crystal.

With these two outfits, Franz proceeded to measure the hardness of the minerals composing Mohs' scale. All of the minerals preceding quartz were scratched with the steel point and for the others a diamond point was used. Franz' note on the diamond is just one line: "den Diamant konnte ich nicht ritzen." (I could not scratch the diamond). He obtained a series of hardness numbers for eight of the crystals used in Mohs' scale. These were all obtained by means of a diamond cone scratcher. Plotting these against Mohs' numbers there results a rough curve like that shown in Fig. 45. As has been brought out by other investigators, the direction in which the diamond point moves with respect to the surface of the crystals will influence the size of the hardness number. Fig. 46 shows that from a given central point the hardness may be represented by the radii vectors drawn from that point. The termini of these vectors show a curve akin to that for the conduction of heat in crystals. Franz found that Seebeck's work corroborated his, but believed that his mechanical device for measuring hardness was an improvement over that of Seebeck.

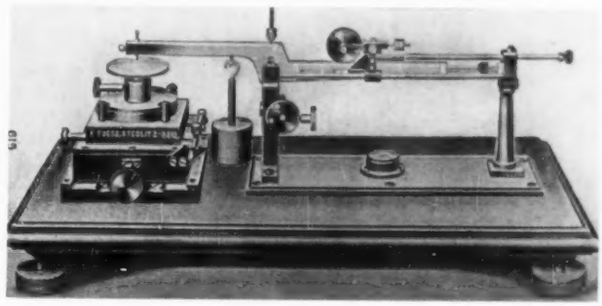

Fig. 47. Hardness testing by the scratch method. Instrument devised by A. Martens.

—Courtesy R. Fuess, Berlin-Steglitz.

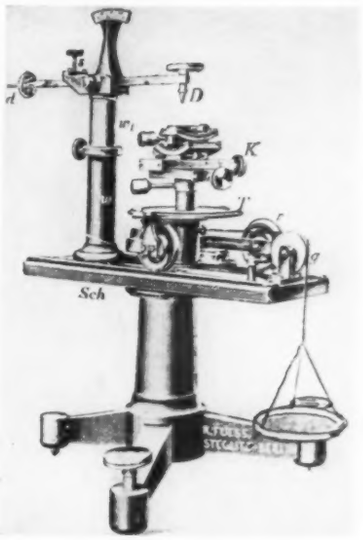


Fig. 48. A scratch hardness tester with a centering head for holding the specimen.

—Courtesy R. Fuess, Berlin-Steglitz.

Martens[16,17] improved on the form of sclerometer. Fig. 47 shows a form as manufactured by the firm of R. Fuess of Berlin-Steglitz. This outfit is arranged to be used in two different ways: (1) In the examination of metals, a measure of the hardness of the material is given by the load which will produce a scratch whose width is 0.01 mm. (2) In the case of minerals and stones the hardness is measured by the load which will give an

*(Continued on page 212)*

16A. Martens, Untersuchung dreier Härteprüfer. *Mitteilungen aus den kaiserlichen technischen Versuchsanstalten zu Berlin*, Vol. 8, 1890, page 215.

17A. Martens, Ueber Härtebestimmungen. *Mitteilungen aus den kaiserlichen technischen Versuchsanstalten zu Berlin*, Vol. 8, part 6, 1890, page 277.

# Installing Liquid Level Indicators

## How Operating Conditions May Modify Pipe Work Connections

By P. B. SHANNON
Development Engineer, The Meriam Co., Cleveland, Ohio

IN practically every industry the level of liquids in tanks has to be measured and controlled—whether it affects important processes or whether it pertains entirely to fire-protection equipment. Liquid level instruments may merely indicate, or they may automatically control pumps or valves. They may be of the Bourdon type and dial form, or of the liquid-column manometer type. Details given below refer to the widely used "well" or "single-tube" type. The basic principle of the manometer when used as a tank gage is that the pressure due to the head of liquid in the tank is transferred to the liquid in the manometer well and is balanced by the column of this manometric liquid.

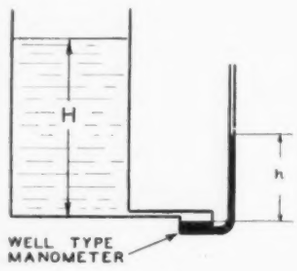

Fig. 1

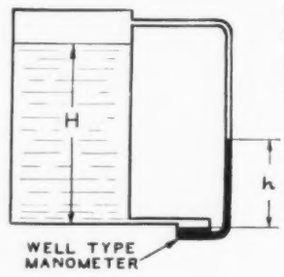

Fig. 2

In some cases it is advisable to have the manometer mounted at some distance from the tank and to run a line from the manometer well, through the top of the tank, into the bottom of the tank. Air is then forced in this line from the manometer to the bottom of the tank and as soon as the air pressure equals the liquid head in the tank, the air will bubble out. Air pressure being the same in all parts of this line, it also acts upon the manometric liquid, causing it to rise in the manometer tube until balance is established. If both the liquid in the tank and the liquid in the manometer are of the same specific gravity, their levels will be equal. If the specific gravities of the liquids differ, as is usually the case, the relative heights will be inversely as their specific gravities. Thus a mercury-filled manometer measuring water tank level will show a rise of only about 1/13.6 of the water height. The manometer scale is, of course, calibrated accordingly. If the dimensions of the tank are known it can be calibrated equally well to read in gallons or other convenient units.

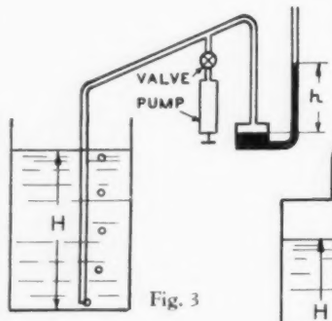

Fig. 3

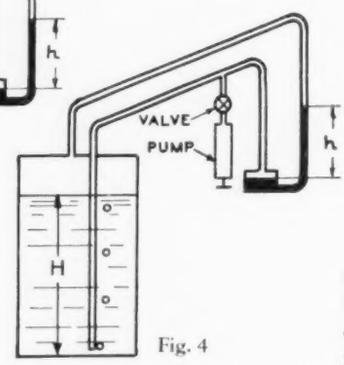

Fig. 4

To determine the length of manometer required, the following simple formula is used:

$$h = H\,S_T / S_M$$

where $h$ = scale length of the manometer in inches;
$H$ = fluid depth in the tank in inches;
$S_T$ = specific gravity of the fluid in the tank with respect to water;
$S_M$ = specific gravity of the meter fluid.

The accompanying illustrations show diagrammatically the installations of manometers on open and closed tanks. They cover practically all types of installations.

Fig. 1 shows the installation of the manometer on an open tank where the fluid is directly on top of the fluid in the well of the manometer. Since the top of the tank and the top of the manometer are both open to atmospheric pressure, there is no need of any connection to the top of the tank. On this installation, the distance $H$ and $h$ vary inversely as the specific gravities of the fluid in the tank and the fluid in the manometer. Fig 2 shows the same installation except that the tank is closed and pressure may exist on top of the fluid in the tank. In this case an equalizing line is necessary so that there will be the same pressure on top of the fluid in the tank and the fluid in the manometer, thereby causing the latter to rise and fall in exact proportion to the rise and fall of the fluid in the tank.

Fig. 3 shows the manometer located at any distance from the tank: the line runs from top to bottom of the tank and over to the well of the manometer. As the fluid rises in the tank, it would also tend to rise in the submerged portion of the line, compressing the air and causing the fluid in the manometer to rise. To obtain correct readings, it is necessary to introduce air until the air bubbles out of the line at the bottom of the tank. This may be done by a hand pump as shown. When the air bubbles out at the bottom of the tank, its pressure equals the liquid head above the point where it bubbles out. This pressure, acting on the fluid in the manometer well, causes it to rise in the manometer tube until balance is established. In this installation the manometer may be either above or below the tank and any practicable distance from it. Fig. 4 shows the same installation except that the tank is under pressure and in this case an equalizing line must be run from the tank to the top of the manometer tube as in Fig. 2.

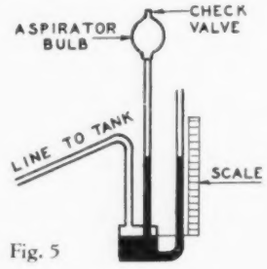

Fig. 5

The Fig. 3 and Fig. 4 installations require the use of a valve, a check valve and a pump. To get away from this complication the Meriam Company introduces the air into the line leading to the bottom of the tank *through the liquid in the well of the manometer,* as shown in Fig. 5, by the use of an aspirator bulb: Air is first forced through the liquid in the manometer well, and upon releasing the bulb the fluid rises in this line (leading to the aspirator bulb) and effectively prevents any loss of air pressure by this liquid seal. The liquid will rise in this line the same height as shown in the glass tube of the manometer; and the scale is calibrated to take care of the drop in the well as the fluid rises in both of these tubes.

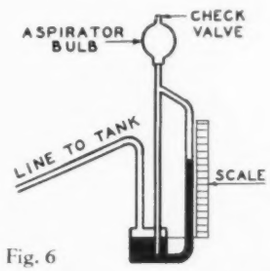

Fig. 6

Fig. 6 shows a by-pass from just below the aspirator bulb to the top of the manometer tube. The purpose of this by-pass is to prevent the fluid being blown out of the gage by introducing air too suddenly into the well of the manometer (before it is equalized in the line leading to the bottom of the tank). With this equalizing line, the liquid is depressed in the glass tube of the manometer when the bulb is squeezed suddenly, and cannot be blown out.

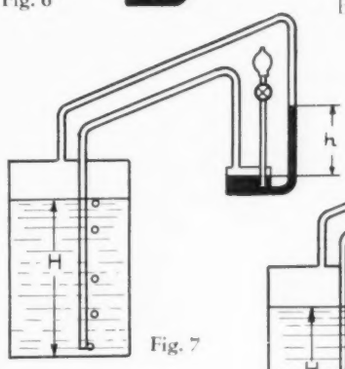

Fig. 7

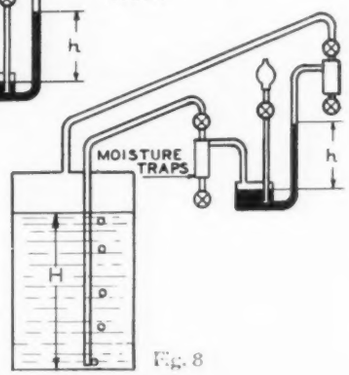

Fig. 8

Fig. 7 shows an aspirator bulb manometer on a tank under pressure. This is for use on storage tanks such as used for gasoline or naphtha where the vapor pressure is only a few ounces. In operating the gage it is necessary to squeeze the bulb, open the valve and force air through the liquid in the manometer well. Then the valve is closed and more air is introduced into the pump, and the operation repeated until the liquid stops rising in the manometer tube. Fig. 8 shows the same type of installation except that moisture traps are provided just ahead of the manometer. This is used where the liquid in the tank may be quite volatile and may condense at atmospheric temperatures. These moisture traps are for the purpose of keeping the condensed fluids out of the gage itself.

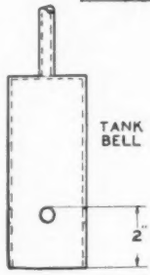

Fig. 9

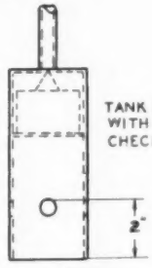

Fig. 10

Practically all tanks collect sediment and dirt in the bottom, making it advisable not to measure the first 2" of fluid. The line leading to the bottom of the tank ends in a tank bell which has openings, the top of which come 2" from the bottom of the bell. The air bubbles out through these openings and consequently the first 2" in the tank are not measured by the gage but the scale reading starts at 2" and reads up. Figs. 9 and 10 show such tank bells. The latter has a float check valve which, if the air pressure should fall in the line, causing the liquid to tend to rise in the tube, would be lifted off its seat and close off the line. This may be desirable on some installations.

Fig. 11 shows an installation where the manometer is some distance below the bottom of the tank and the connection is made from the bottom of the tank to the well of the manometer. In this case it is necessary to correct for the additional head *D* by raising the zero point of the scale a distance on the manometer; otherwise the installation is the same as shown in Fig. 1.

On some installations of tanks under pressure, it is desirable to mount the manometer at the bottom of the tank and to have the same fluid as that in the tank on top of the gage fluid in the glass tube of the manometer. Fig. 12 shows such an installation wherein a seal pot is used at the top of the tank and connection made from this seal pot to the top of the manometer tube. This seal pot is then filled with the same fluid as in the tank and condensation of the fluid in the tank tends to keep the seal pot filled at all times. It will be noticed on this installation that the well of the manometer has been placed at the top and not at the bottom as shown in previous installations so that the zero on the scale is at the bottom. As the tank fills up and the level in the tank approaches the level of the seal pot, the fluid in the manometer tube rises toward the full mark on the scale.

Wherever the pressure on top of the fluid in the tank amounts to 5 lbs. or 10 lbs., it is recommended that a sight-feed bubbler as shown in Fig. 13 be used. Where this sight-feed bubbler is used, it is necessary to run an air line, having approximately 15 lbs. pressure, up to the bubbler, as shown in the last three figures.

Fig. 14 shows a mercury seal between the fluid in the tank and the manometer gage. This installation would be used on naphthalene and other materials which solidify at ordinary temperatures and must be heated in order to become liquid. The mercury seal balances the pressure of the fluid in the tank and by

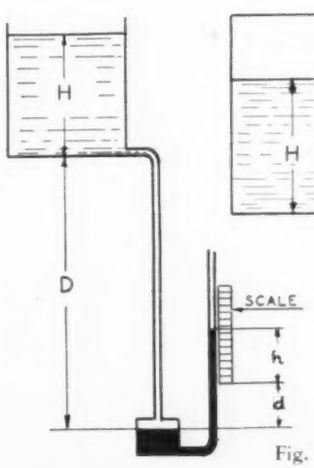

Fig. 11

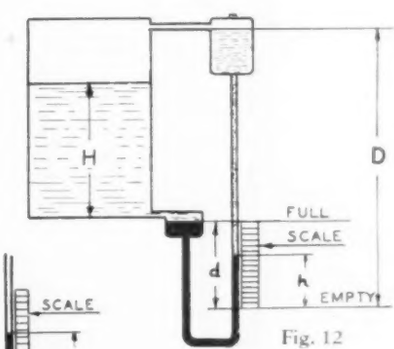

Fig. 12

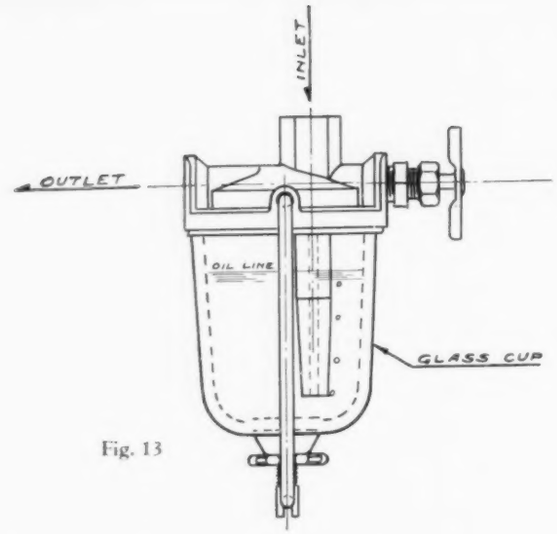


Fig. 13

running a line from the manometer well through the mercury in one leg of the mercury seal, the gage can be calibrated in terms of height $H$ of the fluid in the tank.

Fig. 15 shows the installation of the sight-feed bubbler where it is desired to bubble air continuously into the line leading to the bottom of the tank. In the event the tank is under pressure, it is necessary to have an equalizing line from the top of the manometer to the top of the tank.

Fig. 16 shows an installation on a tank under pressure where a sight-feed bubbler is used and one leg of the manometer is inclined at an angle to give a longer scale reading for the displacement height of the manometric fluid.

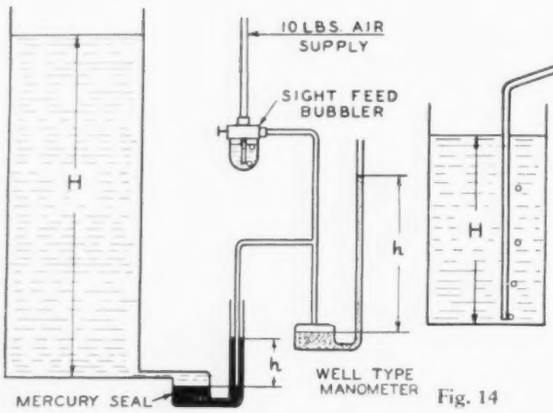


Fig. 14

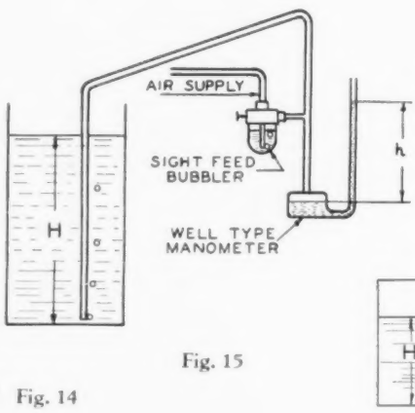


Fig. 15

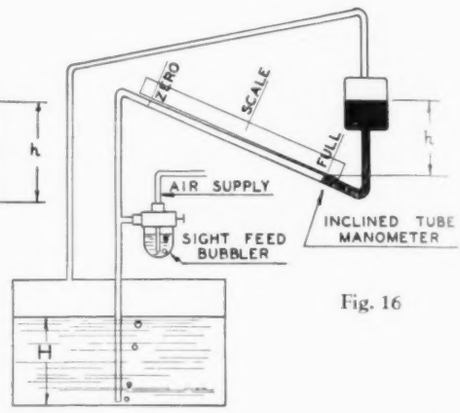


Fig. 16


# THERMOMETER REGULATORS

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## EARLY SCRATCH HARDNESS METHODS

*Continued from page 209*

easily perceptible scratch. In both cases the surface of the material to be scratched is moved along under the diamond point. Fig. 48 shows the instrument with a centering head for the test piece. Fig. 49 shows another form proposed by Hirschwald. There is considerable similarity among these various instruments.

*To be continued*

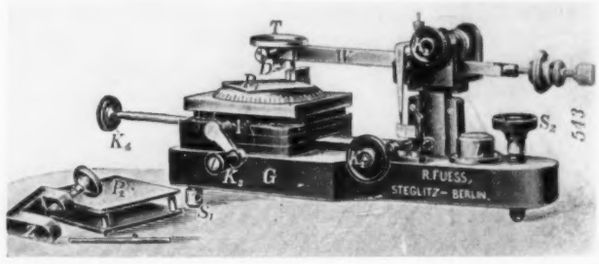



Fig. 49. Hardness testing by the scratch method. Instrument devised by J. Hirschwald.

*—Courtesy R. Fuess, Berlin-Steglitz.*

*See Announcement on Page A2*

# High-Voltage Oscillographs

Twenty-sixth part of "The Cathode-ray Oscillograph and Its Applications" being published serially in *Instruments*. This series began in July 1935 issue.

By RALPH R. BATCHER

**Radio engineer; cathode-ray and electronic application specialist, Hollis, L. I., N. Y.**

The cold-cathode high-voltage cathode ray oscillograph provides the only means available for the complete analysis of short transient potentials and other types of high-speed phenomena, where the whole interval of time involved is of the order of a few microseconds. The demands of accuracy in such research have directed attention toward reliability rather than simplicity. Their relative complexity has prevented their use in the usual laboratory and so only the general details about the tubes and their uses will be given here, notwithstanding their importance in these special fields.[1] These will be followed by some of the important references from the hundreds that have appeared in recent years.

While many styles of construction have been disclosed, in general they all follow the main features first used by Dufour, who pioneered in the development of tubes and processes for this field.[2,3] These oscillographs are characterized by high anode voltages, usually of the order of some 50 kilovolts, and provision for the inclusion of photo-sensitive plates or films within the tube, exposed to the cathode rays by direct impact.[4,5,6,7]

In order to insert or withdraw these films it is necessary to develop a new technique in tube construction and to provide permanently-connected vacuum pumps for re-evacuating after each loading. In many of these designs a plurality of records are possible by reason of the use of a cylinder or a multi-sided drum to which the film is attached, which is rotated by mechanisms operated through airlocks or by magnetic means, so as to bring into position a new, unexposed surface when needed.

The usual tests to which this oscillograph is applied are related to transmission line characteristics, transformer design, circuit breakers, choke coils, lightning arresters, corona losses, etc. In this field, transients of the order of a microsecond duration are usual, while in extreme cases, the successful recording photographically of transients of one milli-microsecond have been reported. Transverse movements of the spot represent speeds up to 300 miles per sec. on the film.

It is evident that at such speeds photographic records only are possible, due to the limitations of ocular vision. The factor which determines the upper limit of recording speed is not the photographic sensitivity of the films obtainable, but the finite length of transit time taken by the electrons in traversing the deflection field. Even at the enormous speeds assumed by the electrons (see Fig. 3, Aug. 1935 article) an appreciable time is consumed during the deflection interval.

Following the work of Dufour, much progress has resulted from a great deal of experimental evidence published by many investigators. These include Norinder, Rogowski, Gabor, George, Knoll, Berger, and the research laboratories of such companies as General Electric, Westinghouse and others.

### DETAILS[8,9,10,11,12]

The outer envelopes of some tubes are composed of a combination of metal and glass sections, while others are all metal except for the insulating bushings. The exceedingly small transit time taken by the electrons in reaching the screen or the photo-sensitive surface simplifies the focusing problem, so that in many cases no auxiliary focusing electrodes are needed—although in some designs a coaxial magnetic field is used to control the focus, connected to an adjustable source of direct current.

The tubes, however, are generally provided with a "beam trap" which permits the prefocusing and adjustment of the ray without premature exposure of the film. The tube, in many tests is left in an operating condition over extended periods, waiting for the transient to appear (such as in the study of lightning surges on transmission lines). Were the ray to be directed toward (or off of) the edge of the screen during such an interval, the stray and reflected electrons would soon fog the film. Even when the ray hits the side of the tube at an angle, a great many electrons may be reflected. Unusual precautions are provided, therefore, toward eliminating these effects.

In the tubes developed by Dufour, this difficulty was overcome by applying the anode voltage simultaneously with the arrival of the transient wave to be recorded. This is still the method used in many commercial forms of this type of oscillograph where the high-voltage anode power supply for the tube is connected through a calibrated sphere gap, which is set at a position a little greater than the breakdown gap required for that voltage. An auxiliary or trigger electrode is mounted in this gap, which is suitably connected to the line or circuit under test, so as to initiate the breakdown at the start of the surge. During the discharge interval substantially full voltage is delivered to the anode circuit. To insure that the cathode emission has reached its normal value, the surge potentials are connected to the deflection system through a time delay circuit, which may be a certain length of the cable under test.

In some designs the ray is directed toward a pocket or cup alongside of the film and at the edge of its possible deflection travel, where it can be entirely absorbed during the waiting interval.

---

[1]Fielder. Some Applications of the Cathode-ray Oscillograph. *Instruments*, Vol. 8, 1935, pages 32-33.

[2]Brown. Radio Frequency Electrical Measurements. McGraw-Hill Book Co., New York, 1931.

[3]Macgregor-Morris & Wright. Accuracy of Measurements with Gas-filled Cathode-ray Tubes. *Journal Institute of Electrical Engineers*, Vol. 71, 1932, pages 57-82.

[4]George. A New Type of Hot-cathode Oscillograph. *Journal American Institute of Electrical Engineers*, Vol. 48, 1929, pages 534-538.

[5]Fortesque, Atherton Cox. Investigation of Lightning. *Journal American Institute of Electrical Engineers*, Vol. 48, 1929, pages 277-280.

[6]McEachron and Goodwin. Cathode-ray Oscillagraph Studies of Surges. *Journal American Institute of Electrical Engineers*, Vol. 48, 1929, pages 374-378.

[7]Miller & Robinson. Cathode-ray Studies of Surge Phenomena. *Journal Institute of Electrical Engineers* (London), Vol. 76, 1935, pages 236-238.

[8]Rogowski & Grosser. Ein Kathoden Oszillographen für Aufnahmen im Vakuum. *Archiv für Elektrotechnik*, Vol. 15, 1925, pages 377-384.

[9]Rogowski & Flegler. Ueber einem Lichtstarken Gluch Kathodenstrahloszillograph. *Archiv für Elektrotechnik*, Vol. 15, 1925, pages 297-303.

[10]Gabor. Fortchritte im Oszillagraphieren von Wanderwellen. *Archiv für Elektrotechnik*, Vol. 18, 1927, pages 48-55.

[11]Rogowski & Wolff. Ein Zeitkipper für den Kathodenoszillograph. *Archiv für Elektrotechnik*, Vol. 21, 1929, pages 645-654.

[12]Peek. Uber einen Empfindlichen Zeitkipper für den Kathodenoszillograph. *Archiv für Elektrotechnik*, Vol. 25, 1931, pages 453-458.

### NORINDER'S ARRANGEMENT[13, 14, 15, 16, 17, 18, 19]

In another arrangement, the development of Norinder, a small target (*t*) is mounted directly in the path of the beam after it leaves the anode orifice (see Fig. 1A). Two deflection plates (*a*) and (*b*) are mounted between the anode and this target, which, when supplied with a suitable d-c. potential, will deflect the ray so that it misses this target entirely. Thereupon it enters the field of either of two additional pairs of plates, which are cross connected with the first pair of plates (plates *c* and *e* are connected to *b*, and plates *d* and *f* are connected to *a*) so that no matter what the extent or direction of the original deflection it is completely neutralized while the ray traverses the second pair. Thereupon it enters the deflection fields, from the normal deflection plate system, in the original axial direction. Whenever the potential is removed from the combination of deflection

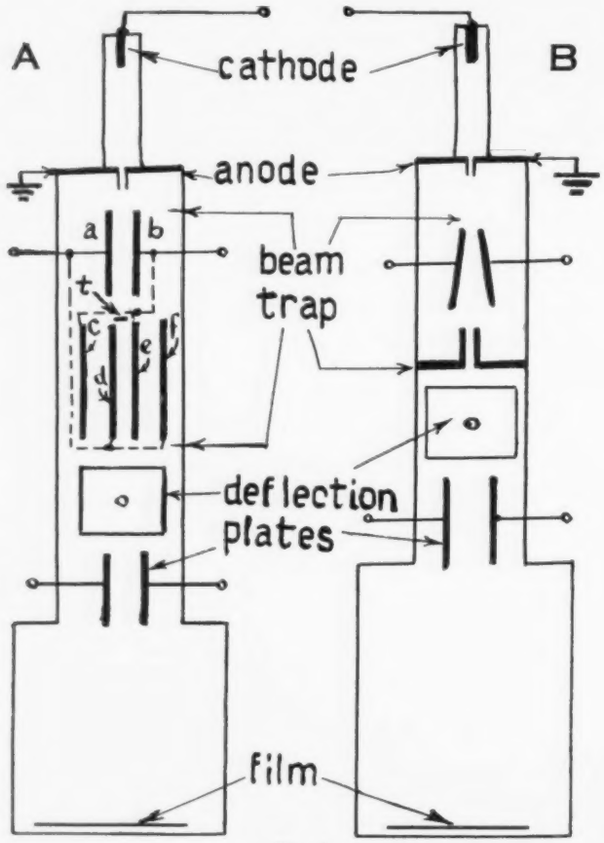



Fig. 1

plates comprising the beam trap, the ray again strikes the target and is absorbed. In the Westinghouse design of this tube (see Figs. 2 and 3) the same results are produced with a somewhat different version of the arrangement shown in Fig. 1A, to be described later.

In another system a beam trap of a somewhat different design is mounted between the anode and the deflection system, as shown in Fig. 1B. Here the beam trap

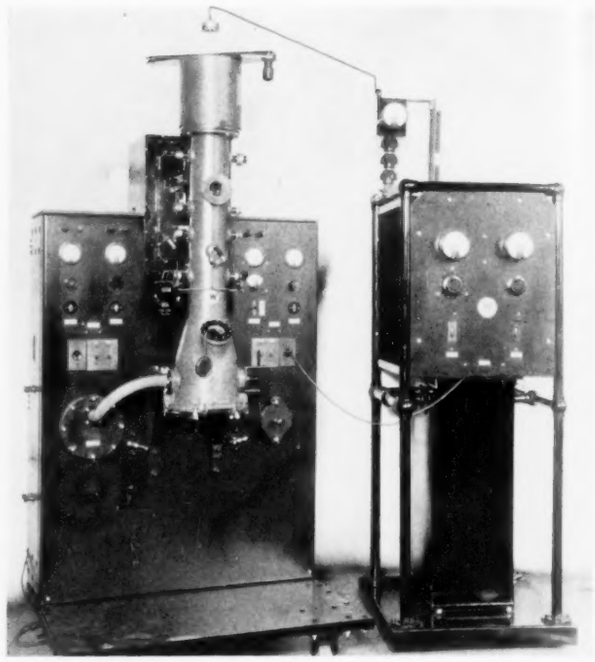


Fig. 2

portion of the tube holds two auxiliary deflection plates and an auxiliary anode diaphragm with a central orifice. A potential applied to these plates will cause the ray to miss the opening in this diaphragm entirely and thus prevent its fogging the film. The removal of this biasing potential will permit the rays to proceed in the normal manner.

### TUBE CONSTRUCTION[20]

While the other parts of the high-voltage cathode-ray tubes are equivalent in principle and function to the parts of the types of tubes described in previous articles, certain differences are noteworthy:

When anode voltages in excess of, say, 50 kv. are used, the difficulty of providing a heated cathode which will withstand the intense bombardment of the ionization, is great. Coiled filaments of uncoated tungsten,

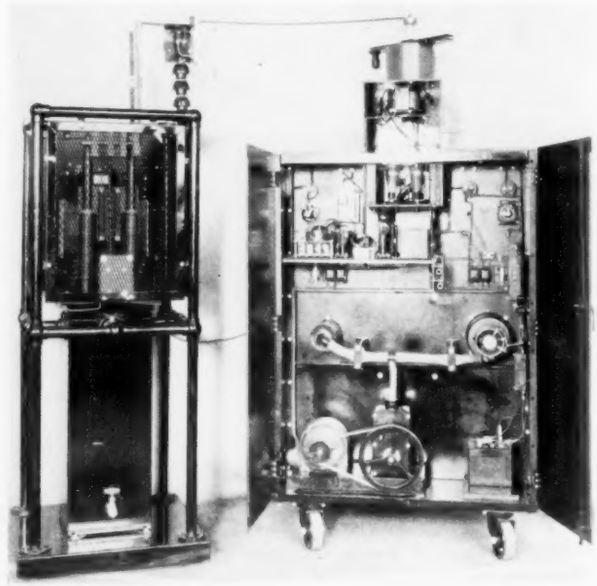


Fig. 3

[13]Norinder. Surges on Transmission Lines due to Lightning. *Journal Institute of Electrical Engineers* (London), Vol. 67, 1929, pages 525-533.

[14]Norinder. Studies of Lightning Surges. *Transactions American Institute of Electrical Engineers*, Vol. 47, 1928, pages 446-450.

[15]Ackermann. Cathode-ray Oscillograph with Norinder Relay. *Journal American Institute of Electrical Engineers*, Vol. 49, 1930, pages 285-289.

[16]Norinder. Determining Lightning Surges. *Journal Franklin Institute*, Vol. 205, 1928, No. 6, pages 747-765.

[17]Harrington & Opsahl. Technique of the Dufour Cathode-ray Oscillograph. *Electric Journal*, Vol. 24, 1927, No. 8, pages 384-388.

[18]Fielder. The Cathode-ray Oscillograph. *Electric Journal*, Vol. 28, 1931, No. 2, pages 106, 107 and 119.

[19]Fielder. The Cathode-ray Oscillograph. *Electric Journal*, Vol. 28, 1931, No. 3, pages 161-164.

[20]McGregor-Morris & Henley. Cathode-ray Oscillography, Chapters 4 and 9. Instruments Publishing Co., Pittsburgh, 1936.

such as used in X-ray tubes, can be used, but the filament transformer must be insulated for this potential difference. Usually, therefore, unheated cathodes are employed, which will operate satisfactorily, or even better in some regards, since a smaller active area can be provided, to decrease the size of the spot. While the life of the cathode is not so important in a tube arranged to be frequently disassembled as it is in the sealed-off variety, changes in the emission efficiency should not be noticeable.

The unheated cathode is usually made of aluminum, which has been found to be one of the most efficient of the easily worked materials. It must be frequently polished to remove the pitted surface; and also, after each few hours' run, to remove irregularities due to the vaporization from the gas ionization.

In some cases the difficulties found in keeping a heated cathode active have been overcome, it is claimed, so that cold-cathode emitters in high-voltage ($> 50$ kv.) tubes are by no means universal.

Since the tube must be frequently re-exhausted there is usually no attempt to include special gases, other than natural air, although some exhaustion processes leave mercury vapor. Other gases, especially hydrogen, may be used to improve the focus.

The pumping means associated with each installation do not permit high evacuation, but a certain gas pressure is necessary with cold-cathode operation; a pressure of the order of 10 or 20 microns is commonly used, but the actual value can be altered to control the emission current to the value found desirable for the particular design. Small changes in the operating pressure will produce large changes in the operating characteristics, especially the anode currents.

### REQUIRED EMULSIONS[21, 22]

High-voltage rays will record on practically every type of photo-sensitive emulsion, but when extremely rapid transverse deflections are to be recorded, the use of special plates (such as halftone plates or the special Schumannized type) is advised. The depth of penetration of the rays into the emulsion, for extremely rapid transverse movements, is proportional to the square of the electron velocity. This accounts for the extremely high anode potentials necessary with this type of tube, since an anode voltage of 60 kilovolts is but five times as effective as an anode voltage of 2400 volts.

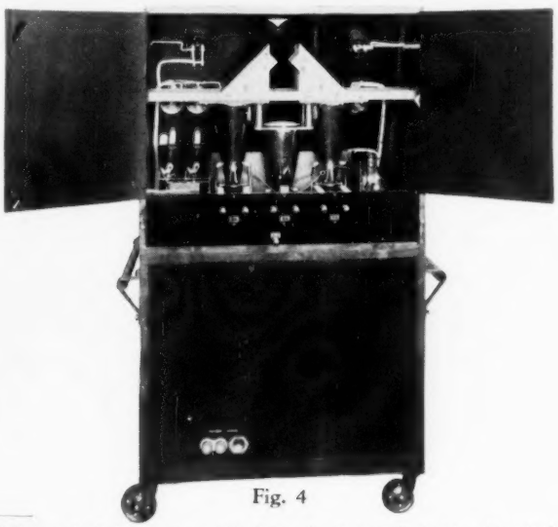


Fig. 4

[21]Rogowski & Ruhlemann. Die Braunshe Rohre als Sichtquelle. *Archiv für Elektrotechnik*, Vol. 24, 1930, pages 691-692.

[22]Rogowski & Szegho. Ein Abgeschmolzenes Braunschen Rohren Hoher Leistung. *Archiv für Elektrotechnik*, Vol. 24, 1930, pages 899-900.

Fig. 5

MEDIUM-VOLTAGE SEALED-OFF TUBES

While the internal application of the recording films into the direct path of the rays is the usual practice, there are numerous instances of satisfactory designs using fluorescent screens in a sealed off tube. While for strictly equivalent results the latter method requires several times as much beam energy, recent improvements have extended the actinic ranges of both the films and the screen to permit the use of the sealed-off type of tubes in many tests.

Several new oscillograph designs have been disclosed by the General Electric Co., which illustrate the possibilities with sealed-off tubes, arranged to use anode potentials of the order of 15 kilovolts. An automatic cathode-ray oscillograph (Type HC-15) arranged to record surges arriving at an unknown time, is shown in Fig. 4. Three high-vacuum cathode-ray tubes having fluorescent screens of the persistence type are utilized. The method used is as follows: A time base oscillator, having the usual linear characteristics and a frequency range sufficient to cover the test range found in practice, is applied to one or more of the tubes in the oscillograph. The normal potential or current waves found in the system are thus continuously depicted on the screens. Most of the high-tension transmission line studies are multi-phase and any phenomena occurring on one wire are intimately linked to associated effects in the other phases. For this reason a complete analysis of the effects is possible only with a three-phase oscillograph. The individual tubes in this model are therefore connected to the common time base and to the respective phases of the system.

By means of the mirror system (shown in Fig. 4) all three fluorescent screens can be photographed with a single camera, the lens shutter of which, normally closed, is triggered open to record any abnormal occurrence. This shutter is operated by a Thyratron-controlled relay actuated by the disturbance. The particular fluorescent material on the screen retains the image long enough to insure that it is recorded after the operating interval.

In another design, developed particularly for the purpose of recording recovery voltages on power systems in connection with expulsion-gap tests, the G-E three-tube oscillograph (Fig. 5), high-vacuum 15-kilovolt tubes are

mounted vertically and adjacent, using a common excitation voltage. The oscillograph is portable and requires only a 110-volt a-c. supply. Rotating-drum-type magazine film holders are provided for each oscillograph tube using 35-mm. motion picture film. As many as 75 three-phase or 225 single-phase tests, may be made without reloading. The films are transferred to a magazine in daylight and may be developed as taken or allowed to accumulate. The three drums are driven coaxially through flexible couplings at a suitable speed for recording the phenomenon being studied up to a maximum speed of about 100 ft. sec. or 30 microseconds per millimeter. At this speed, one cycle of a 30,000-cycle oscillation occupies approximately one millimeter. If the Lissajous-figure method of recording is used, with the film stationary, then 400 exposures may be made with each film holder without reloading. The cathode beam may be automatically initiated by the transient to be measured, or from other control circuits. This is accomplished by means of a thyratron tube circuit, which acts on the control grid of the cathode-ray tube. The initiating circuit may be tripped by as little as 12 volts and is adjustable for exposures of various durations to correspond with the film speed used. Full-scale deflection is obtained with 1500 volts.

Fig. 6

Fig. 6 shows another new general-purpose oscillograph (G-E) using a single tube, arranged for either visual or photographic recording. A high-speed rotating film drum with motor drive and speed-indicating equipment is available where the moving film type of recording is required. Standard auxiliaries provide for automatic time co-ördination, several time-axis adjustments and time-axis and deflection amplitude calibrations.

### OSCILLOGRAPHIC RECORDING USING THE LENARD WINDOW[23, 24, 25, 26]

An intermediate method uses the Lenard ray window, through which the rays pass to an external photographic film. Since the windows in many of these tubes are not vacuum-tight, re-exhaustion at frequent intervals is also necessary, so that this method has not received the attention that has been accorded other types. Other objections are the limited area of the window, and the rapid dispersion of the ray after it reaches the air. On account of the fragile nature of the window, the film or plate cannot be placed directly against it so that some dispersion is inevitable.

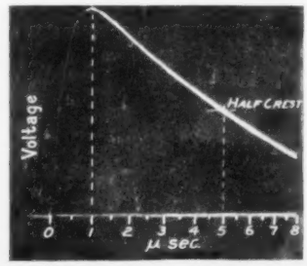
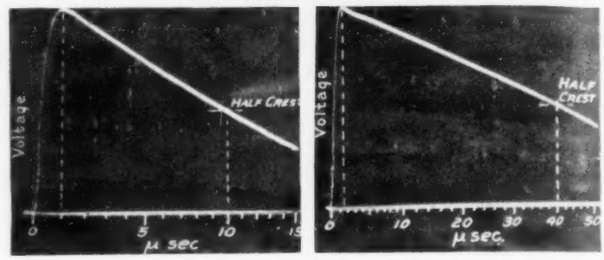



Fig. 7



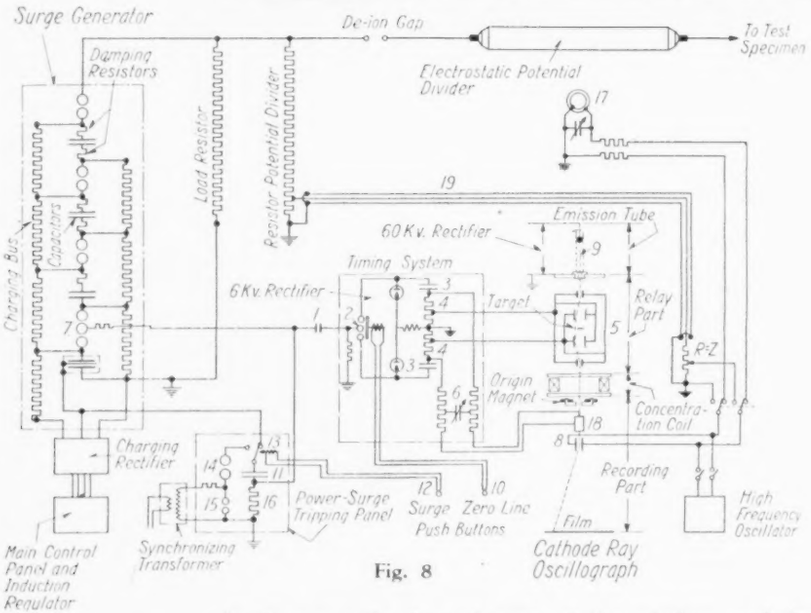




Fig. 8

### APPLICATIONS[1, 27, 28]

It happens that the most important type of application for this type of oscillograph is the measurement of transients associated with high-voltage circuits, which surges, although occupying a short interval of time, have relatively large potential amplitudes. Therefore the low deflection sensitivity resulting from the use of high anode potentials is not a disadvantage. In fact the surge potentials are of sufficient amplitude that elaborate deflection control circuits are often necessary in order to keep the deflection within the limits of the recording film surface.

[23] Knoll. Aussenaufnahmen von Kathodenstrahlen Oszillographen durch Lenardfenster *Zeitschrift für Technische Physik*, Vol. 10, 1929, pages 28-30.

[24] Knoll. Vakuum Technische Neuerungen an Kathodenstrahlen Oszillographen. *Zeitschrift für Technische Physik*, Vol. 10, 1929, pages 294-299.

[25] Knoll. Kathodenstrahl Oszillographen mit Lenardfenster. *Elektrotechnische Zeitschrift*, Vol. 50, 1929, No. 33, page 1207.

[26] Knoll, Knoblauch & Borries. Fortschritte am Kathodenstrahl Oszillographen durch Dauerbetrieb mit Metallentladungsrohre und durch aussenphotographie sehr Kurzzeitiger Vorgaenge. *Elektrotechnische Zeitschrift*, Vol. 51, 1930, No. 27, pages 966-970.

[27] McEachron. Characteristics of Lightning Arresters. *General Electric Review*, Vol. 29, 1926, pages 678-684.

[28] McEachron and Wade. Time Lag Studies in Needle Gaps. *Transactions American Institute of Electrical Engineers*, Vol. 44, 1925, pages 832-844.

Research in most of these fields can be accelerated by the use of staged tests, where the impulse or transient to be studied is simulated by special generators as often as desired. This permits the recording means and the timing wave to be started at the exact instant required for successful recording. Present knowledge of impulses due to switching, lightning surges, etc., has indicated that their effects can be simulated by pulses generated by special means so that their waveform can be carefully controlled. For example these impulses can be produced by charging a number of capacitors in parallel, and discharging them in series across spark gaps. An infinite variety of wave shapes can be produced by varying the capacitance value, the voltage level, and the discharge resistance and the manner by which it is coupled to the transmission line or other apparatus under test. Three representative wave shapes have been standardized by the A. I. E. E. in which both the wave front interval (the time required for the wave to build up to its peak, measured in microseconds) and the decay period (measured from the crest to half amplitude) are defined. These standards are illustrated in Fig. 7, showing waves in which these intervals are: 1 $\mu$s. plus 5 $\mu$s., 1 $\mu$s. plus 10 $\mu$s., and 1.5 $\mu$s. plus 40 $\mu$s. respectively. These time intervals are marked on the oscillograms. They are produced by the apparatus shown in Fig. 8, which is part of the Westinghouse commercial oscillograph.

In this system (Fig. 8) each of the basic condensers in the surge generator has a rating of 100 kv and a capacitance of 0.25 mfd. Inasmuch as the operational procedure in making these tests is in general similar to that used with other types of apparatus, it will be described briefly. First, the condensers in the surge generator are charged to the required potential, controlled by the setting of the master spark gap 7, associated with this item. The other gaps break down immediately and the condensers all discharge in series, initiating a surge which is applied to a load resistance and to other apparatus under test. At the same time a pulse (about 2000 volts) is applied to the timing system through a coupling condenser 1, breaking down the gap 2. The ionization of this gap discharges the two condensers 3 in series, which have been charged by an independent source. The potential appearing across the resistors 4, starts to charge timing circuit 6, causing a voltage to build up on condenser 6 and on the deflection plates 18 inside the cathode-ray tube. At the same time a few hundred volts are applied to the beam trap deflection plates to cause the electron ray to avoid striking the target, as heretofore described.

The potential of the surge generator can be applied to the oscillograph through a resistor type potential divider. A short length of delay cable is also added to prevent any deflection due to the deflection plates 8 until the beam trap has functioned. The necessary delay is a fraction of a microsecond. This takes a picture of the normal surge waveform.

In other tests the surge may be applied to the test specimen upon which there may be already alternating current potentials. In order that the surge be applied at a known point on the power line cycle, the discharge is initiated by an auxiliary potential from a synchronizing transformer delivering a potential whose peak occurs at the predetermined point by proper phasing control. In this case the surge resulting from the combined conditions is applied to deflection plates 8, through electrostatic potential divider 17, to preserve the actual waveform conditions. The elements of the cathode-ray tube shown correspond to the details of the tube shown in Figs. 2 and 3. The housing of this cathode-ray tube consists partly of a steel casting and partly of a seamless steel tube, which effectively shields the ray from all external electrostatic fields. Tube controls, including those associated with the Norinder type beam trap, the coaxial magnetic focusing coil, the timing wave sweep circuit and an auxiliary high-frequency oscillator for timing purposes are all contained in this apparatus, together with the vacuum pump equipment.

### DEFLECTION CONTROLS[28, 29]

The problem of securing recording accuracy in the measurement of rapid transients depends largely on the method used to secure the proper deflection potentials without introducing a distortion of the waveform. The received surges may reach amplitudes of hundreds of kilovolts. In some cases the other extreme may be found: requiring some amplification.

Minor changes in the deflection sensitivity can be accomplished by altering the size or spacing of the deflection plates in some tubes, but this method cannot be used to secure an extensive alteration of the amplitude. It also is possible to secure minor changes by varying the anode potential. In general, however, some type of voltage divider circuits is necessary. Although high-voltage tubes are of the gas-filled type, the metallic walls used in their construction usually reduce stray ionization so that interplate impedances are only capacitive, if the deflection-plate potentials are kept below a few kilovolts. If higher voltages are applied to the plates ionization will occur at that point.

The question of deflection amplitude control has been studied by many investigators. Voltage dividers may be of the resistive type, capacitive type or a combination of both. The resistances may be wire wound or of the fluid type, but in any case should be arranged so that their inductive and capacitive effects are at a minimum since the high-frequency equivalent of a surge may be as high as several megacycles. It may also be necessary to make corrections to compensate for the ground capacity in such cases.

A somewhat different method that offers considerable promise utilizes a piezoelectric transformer. A quartz plate is cut so that its thickness dimension (an "x-cut" crystal for example) is sufficient to withstand the potentials under investigation. This potential is applied to two metallic electrodes applied to the faces in the usual manner (soft metal strips, such as tin foil, should not be used however). The physical dimensions of this plate will vary in proportion to the applied potentials, and these movements are utilized to actuate another crystal which acts as the secondary of the transformer. Compressional waves thus applied induce electrical potentials in the latter crystal which can be applied to the deflection system.

The upper limit of the potentials measured with such a device in the writer's experience, was about 40 kv applied to the driving crystal 0.5 cm. thick. It was used in making potential measurements in the radio-frequency circuits associated with electro-therapy apparatus. The transformation ratio is proportional to some constant (apparently about 1%) multiplied by the ratio of the secondary and the primary crystals. While literature abounds with references to piezoelectric effects, little has been found that bears directly on this application.

*To be continued*

[29]Peters, Blackburn & Hannen, Voltage dividers and their use with Cathode-rays, *Bureau of Standards Journal of Research*, Vol. 9, 1932, pages 81-114.

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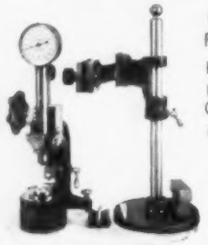

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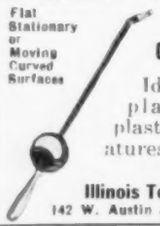

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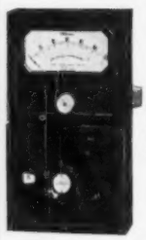

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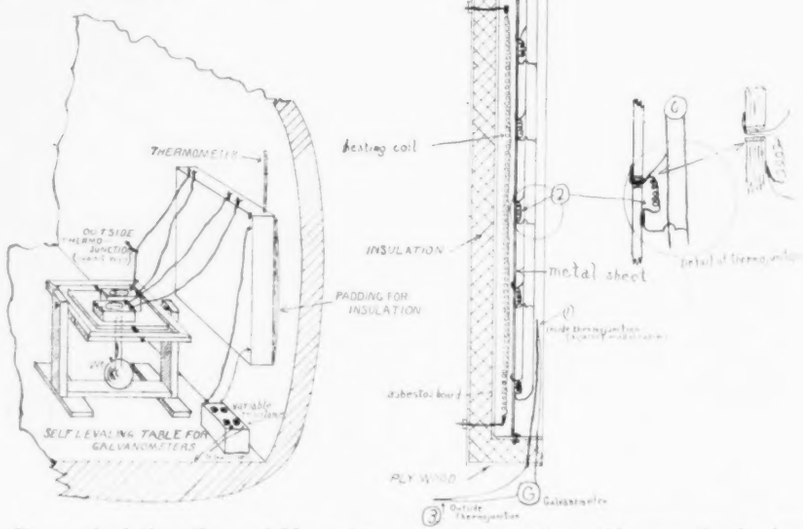
The principle is: The heat flowing through a solid body is equal to the heat flowing through any plane of the body perpendicular to the flow.

The box of the instrument is placed against the wall. The heating coil is heated by a controlled current until the chamber on the right (fuselage) side of the metal plate is at the same temperature as the outside air. When this is so the wall covered by the chamber will be at same temperature as the wall outside the box. This condition is indicated by a thermocouple having one couple against a sector of the wall covered by the box and another against a nearby section of wall outside. When the galvanometer reads zero the 2 junctions are at the same temperature.




By manipulating the variable resistance in the circuit with heating coil and power supply, the temperature of the chamber next to wall can be varied.

When the heat inflow is balanced against the heat outflow the rate of flow can be measured. Note that the box is well insulated so heat can escape only through the fuselage wall.

There are two ways to measure the flow once the coil is balanced:

(a) Measure voltage drop across coil and amperes through it. Input = Output. If the current supply is not steady but "jerky," this method will not work since current and voltage cannot be measured accurately.

(b) Measure the temperature difference between opposite sides of the metal sheet *at its surfaces*. Then knowing thickness, conductivity constant, and area, the rate of conduction is calculated. The temperature difference is measured by a battery of thermocouples arranged in pairs over the surfaces of the sheet and connected in parallel to a galvanometer. For best results the device should first be used with mercury in glass thermometers on opposite sides of the sheet with bulbs touching it and the rest projecting out where the pair can be read. Once the approximate difference is known the type of thermocouples and galvanometer to be used can be determined. Then the whole sheet should be rigged with thermocouples and galvanometer and tested in the laboratory with standard temperature differences to calibrate the instrument for actual use.

It would appear easier to equip the plane with constant power batteries rather than prepare the instrument for the second method of measuring.

Even if it is to be used with the first method the metal plate cannot be dispensed with. Without it radiant heat from the coils would warm the fuselage without registering all the heat as increased air temperature at the surface.

Temperature of the cabin and the outside air as well as the air speed should be noted with each set of readings otherwise the conductivity constant of the wall cannot be determined. The cabinet of the

*(Continued on page 219)*

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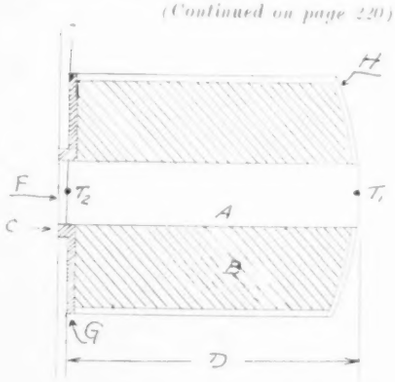
$$\Delta H/\text{hr./sq. ft.} = K\,(T_1 - T_2)/D$$

where $\Delta H$ is in B.T.U., $t$ is in degrees F., and $D$ is in inches.

Now referring to the accompanying diagram:

$A$ is the conductor for which $K$ is known and along which we are going to determine the temperature gradient;

*(Continued on page 220)*





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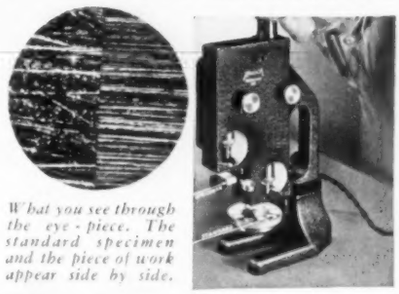

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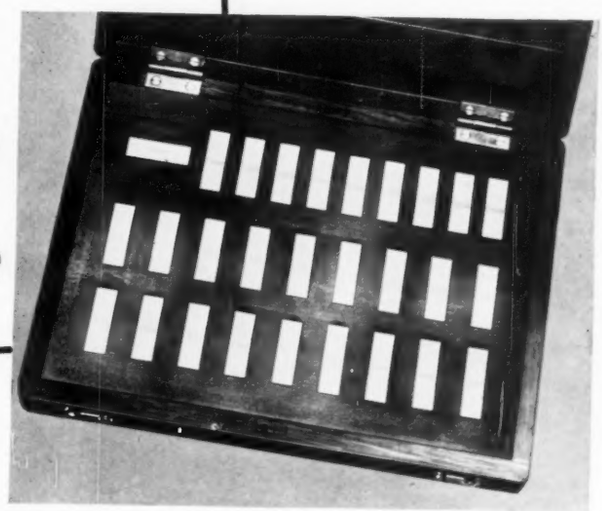

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- ★ 400 volt power supply for amplifiers and sweep.
- ★ Separate 1100 volt rectifier for Cathode Ray Tube.
- ★ Internal or external positive synchronization.
- ★ Terminals provided for direct connection to deflection plates for D. C. and R. F. signals.

*For Complete Information Write*

**Allen B. Du Mont Laboratories, Inc.**

**Upper Montclair, New Jersey**


$B$ is Kapok insulation between core $A$ and shell $H$ which is attached to $A$ at $T_2$ ($H$ will be very nearly at the temperature of the air in the plane;

$C$ is an insulating bushing between $F$ and the rest of plane lining;

$F$ is of the same material and outer finish as the rest of the material lining the plane;

$G$ is an insulating bushing serving to center $F$ in its opening.

A thermocouple can be mounted on the shell $H$ having two similar wires connected at $T_1$ and $T_2$ using the block $A$ as the other branch of the couple; i.e. if block $A$ is of Advance metal, then the thermocouple wires should be of copper.

In practice we determine $T_1 - T_2$ from the galvanometer deflection. Knowing $K$ and $D$ this enables us to compute the heat loss per hour per square foot from the inside of the plane through $A$ and $F$ to the outer air. Now if $F$ is of the same outer finish as the rest of the inner wall, it is reasonable to suppose that just as much energy will be radiated from $F$ per unit area as by any other part of the inner wall.

The sensitivity of the device can be varied by merely varying the area of $F$ and the cross-sectional area and length of $A$. The instrument can be used to determine the rate of heat loss at various parts of the plane by merely providing properly sized holes at the points where it is desired to take readings. The holes could be covered with swinging covers when not in use.

The sole disadvantage of this type of instrument would lie in the possibility that heat from the observer's hands might give an apparently high value of $T_1$. Another factor which might be a deciding point in a rejection of a device of this type is the length of time during which the instrument would have to be left in position in order to attain an equillibrium reading.

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### $5 PRIZE SOLUTION

By WILLIAM R. RYAN
NORTH BERGEN, N. J.

A light sheet metal box should be constructed as shown in Fig. 2, and should be 12" square inside, about 2" deep, and with walls about 3" thick. The space between the walls of the box should be packed with some good insulating material such as mineral wool, magnesia, or kapok, and provision should be made to mount the heating coil and glass thermometers. The face of the box that fastens to the fuselage can be covered with soft rubber and lugs can be provided on

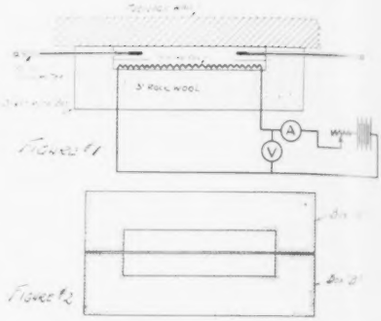


Figure 1



Figure 2

the outside of the box so that it may be drawn up snugly to the inside of the fuselage. The operation is as follows: The temperature inside the box is raised about 30° or 40° above the inside temperature, or whatever value is used when the box is calibrated. When conditions have become stabilized the input to the box is calculated from the ammeter and voltmeter readings and is converted to BTU/hr. The heat loss from the box to the inside of the fuselage will be known from a previous calibration and by subtracting this from the total input the heat loss through the fuselage wall will be obtained in BTU/hr. The outside air temperature should then be obtained with a wing thermometer and the heat loss calculated as BTU/hr/°F. difference. As the box is 12" square inside the heat loss will then be expressed as BTU/hr/sq. ft./°F. difference, which will be the overall heat transfer coefficient for that section of fuselage wall. The heat loss from the box may be determined as shown in Fig. 2. Another box, similar to the first box but without heating coils and thermometers can be constructed and the two boxes fastened together. The temperature inside is raised to 30° or 40° above room temperature and after conditions have become steady the input is measured and converted to BTU/hr. This heat loss divided by 2 will be the value that is to be subtracted from the total input when testing a section of fuselage wall. It should be noted that whatever temperature increment above room temperature is used when the box is calibrated should also be used in testing. The airplane should also be cruising at a constant speed when taking measurements so that the outside film coefficient will remain constant. A method similar to this has been used with good results in measuring heat losses through furnace walls.

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**Problem No. 10** **Subject Index 2.10**

### FORMALDEHYDE GAS DETECTOR

**Large chemical laboratories are interested in "the continuous testing of atmospheric air to discover the presence of toxic or harmful ful amounts of formaldehyde gas. The device should an alarm whenever the determined limit is exceeded. It would also be desirable to record continuously the amount of formaldehyde present."**

Five dollars will be paid for every solution (or critical discussion clearly pointing the way to a solution) which is accepted for publication. Address Instrumentation Forum, 1121 Wolfendale St., Pittsburgh, Pa. Type double-space, on one side of paper. Draw diagram in black ink on separate sheet. Mail before September 15. Solutions and discussion accepted will appear in October 1937 issue.